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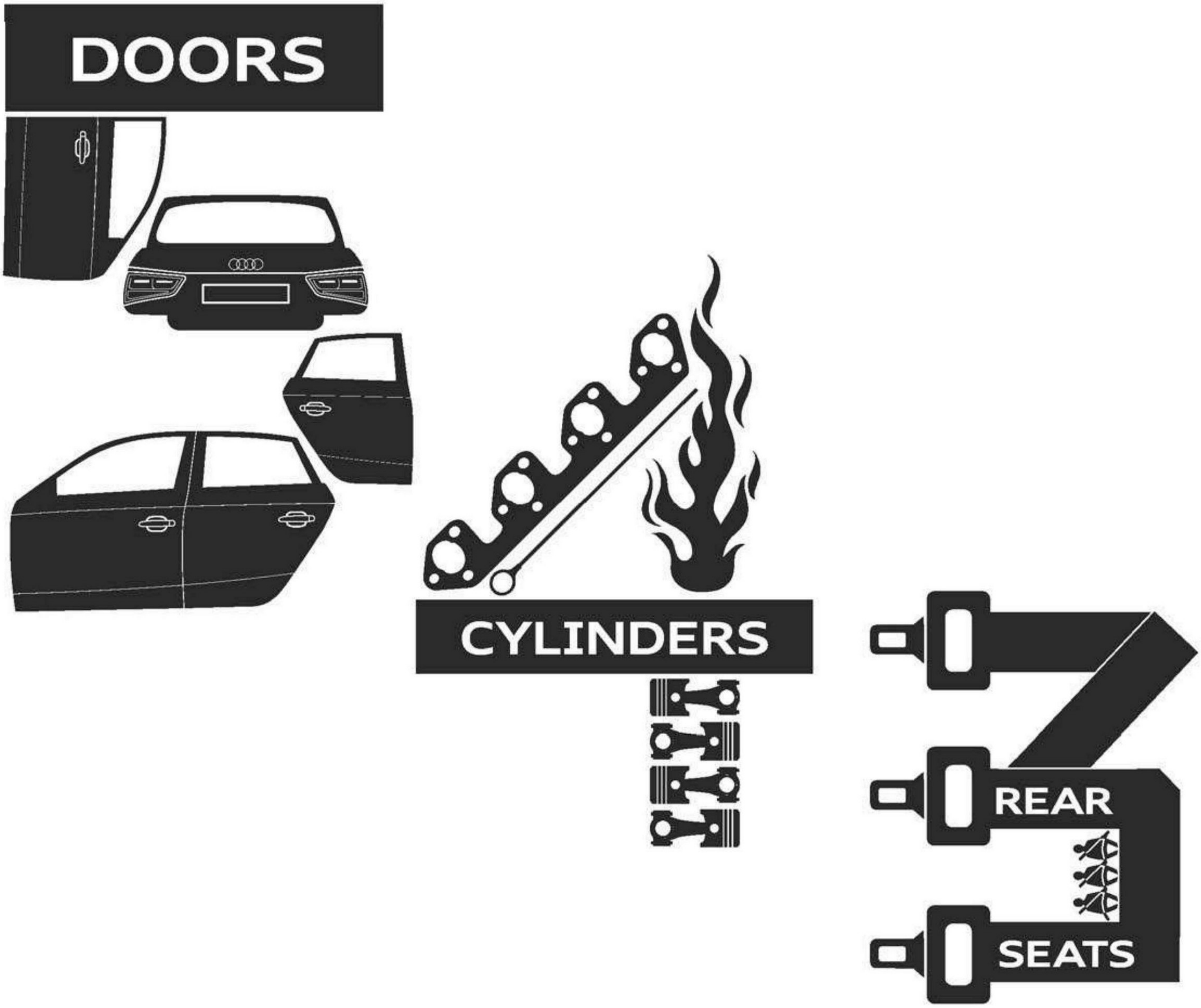

Official fuel consumption figures for the new A1 Sportback range in mpg (l/100km) from: Urban 37.7 (7.5) –
For more information visit audi.co.uk/A1Sportback. Xenon lights are optional equipment.

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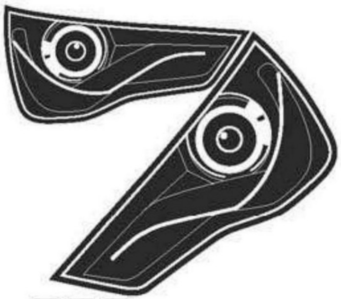

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64.2 (4.4), Extra Urban 55.4 (5.1) – 83.1 (3.4), Combined 47.9 (5.9) – 74.3 (3.8), CO_2 emissions 139 – 99g/km.

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"There is a fundamental reason that you can never live on as bits and bytes: it is that you are an animal, *Homo sapiens*" – *Stephen Cave*

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Right: Michael Acton Smith, CEO, Mind Candy

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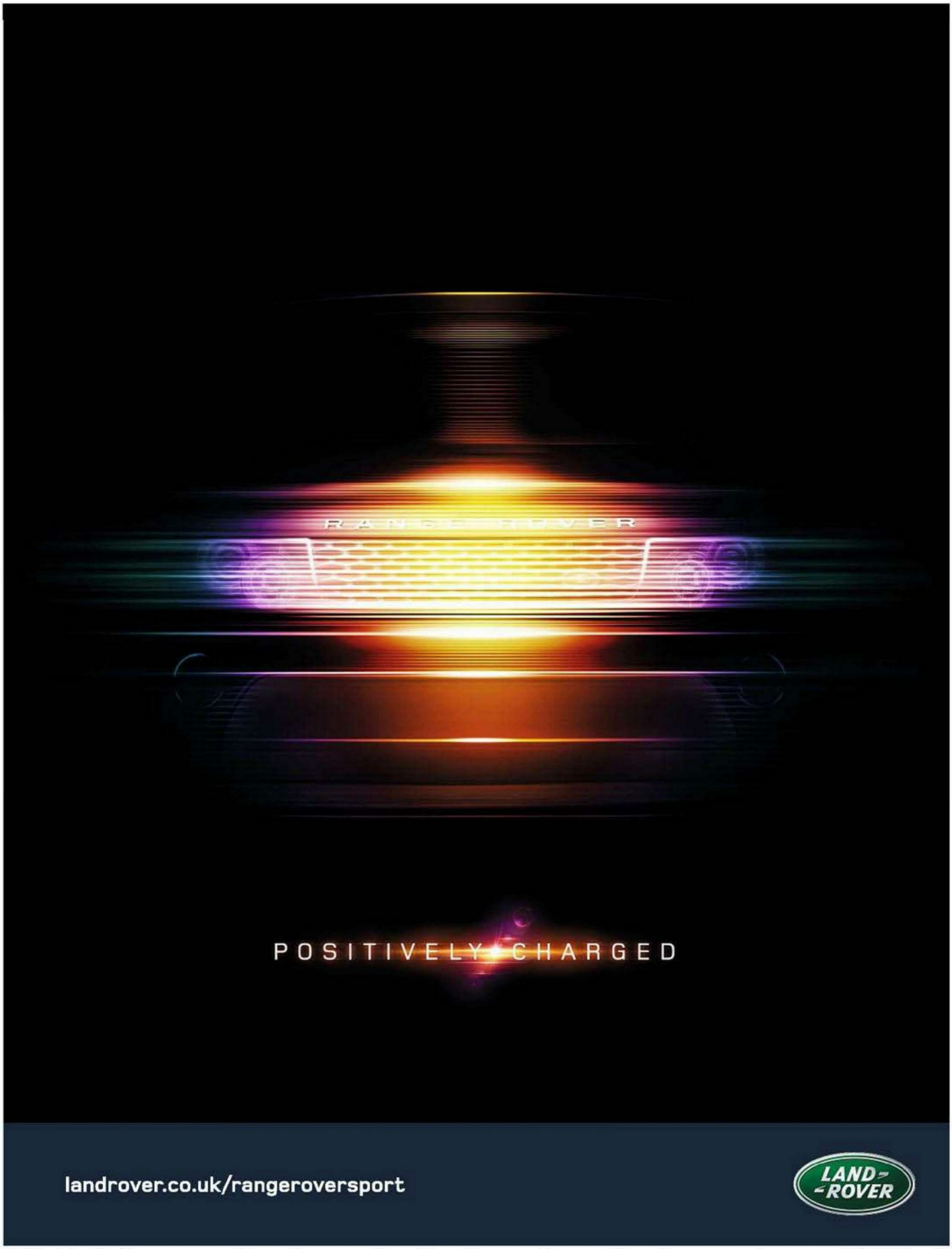
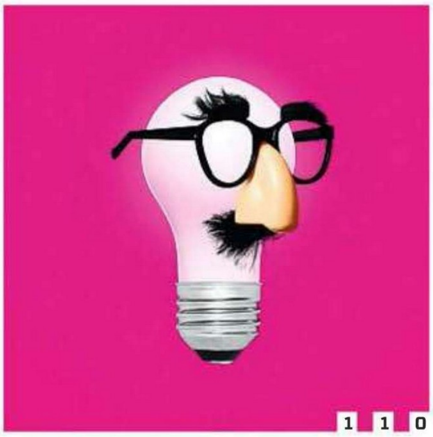
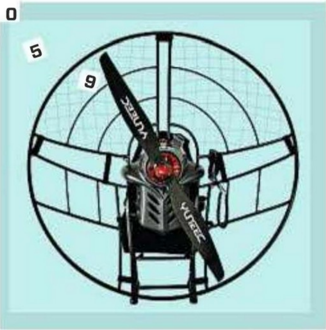


landrover.co.uk/rangeroversport

Official fuel consumption figures for the Range Rover Sport range in mpg (l/100km): Urban 13.0 (21.8) – 28.8 (9.8), Extra Urban 26.3 (10.7) – 34.9 (8.1), Combined 19.0 (14.9) – 32.1 (8.8). CO_2 emissions 348 – 230g/km. Drive responsibly on and off-road.





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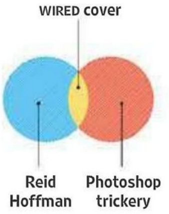

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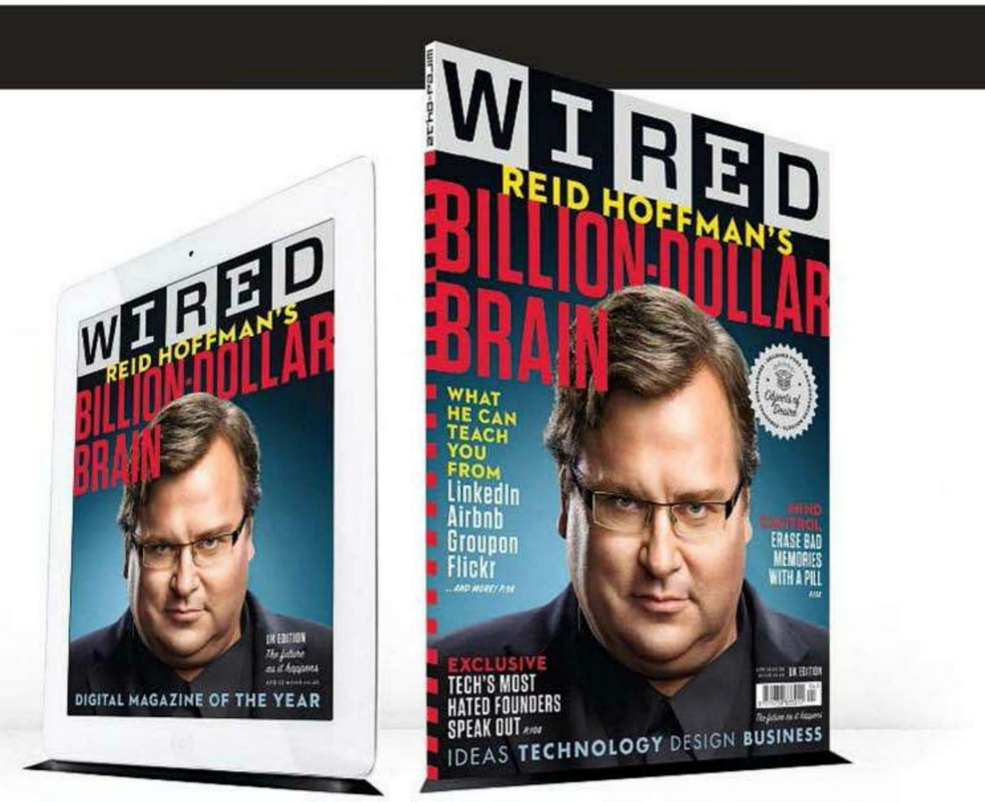
Our 04.12 cover generated some lively debate on authenticity...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WIRED TWEETS

Fascinating itw of Hoffman in *@WiredUK*. Inspiring to see someone lead a life abiding by a self-determined philosophy. *@KHelioui*

Love this quote from Reid Hoffman in *@WiredUK* "throw yourself off a cliff and assemble an aeroplane on the way down." *@Markle875*

Enjoyed *@irowan*'s profile of *@quixotic*. It also serves as a series of short restaurant reviews. *@brokenbottleboy*

The *#kranium* crash helmet in *@WiredUK* looks great but what happens when it rains? *#soggy* *@ne_brown*

04.12 Reid Hoffman's billion-dollar brain. The "best-networked man in Silicon Valley" talked to WIRED about his staggeringly successful life of entrepreneurship and investment. But, he says, all he ever wanted to be was a philosopher. Any budding philosophers out there willing to trade places with him? **Contact us: rants@wired.co.uk**

TRUST THE FEMALE SPEAKER

Not to nay say, but the pragmatic and rational don't always address the emotional or cultural (Where are all the women conference speakers?, 04.12). As children's studies still find, girls are largely accepting of watching male characters in film and television, but boys are less accepting of watching female characters. Take this up a generation, where for mass-market paperbacks males rarely read books by female authors, yet females will read equally both male and female authors. By extension, it is regrettable but logical that speakers at conferences are primarily male, as they are sought after and listened to by both genders. Culturally, it will take more time to achieve emotional and perceptual equality, no matter how rational the argument is. It will continue to evolve but we're decades away from the vision presented in Sarah Szalavitz's article. *Jezzie, via wired.co.uk*

SAMWERS: A FORCE FOR GOOD

After many press reports on the Samwers, this is a well-rounded piece that doesn't forget to put emphasis on the fact that the brothers have been the key influence in Berlin becoming a startup hub (Inside the clone factory, 04.12). I am a student at the WHU-Otto Beisheim School of Management where Oliver Samwer studied and recruits heavily. Many WHU students start at Rocket Internet to gain experience, then go on to launch their own innovative startups. Its Entrepreneur in Residence programme is producing many good founders who would have otherwise joined investment banks or consultancies. *Marc Boehm, via wired.co.uk*

I'm thinking of setting up a guys-only social network (Sorry, boys..., 04.12). Football, Page Three girls, and *Top Gear*, anyone? *Jake Etheridge, via email*

What Jonah Lehrer forgets to mention (The Forgetting Pill, 04.12) is that the theory that memories are recreated again and again comes not from Donald Lewis and Karim Nader, but from Sigmund Freud. *Karin Lesnik-Oberstein, via email*

UNDO

John D Kubiatowicz reports that a Kindle full of ebooks is 10^{-18} grams more than an empty one, and not as stated (The WIRED Index, 04.12).

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Kelli Anderson

Brooklyn-based Anderson illustrated a matrix of the "Hot Chicks Doing X" meme. "Like the 'Shit X Says' videos, it's an arms race to apply a popular format to increasingly niche sub-audiences," she says. "Yes, some women are trying to fit the idea of 'Hot Chick-ness' – but the 'Hot Chicks of Occupy Wall Street' were recontextualised by dudes who need page views."

Andrew Simpson

Based in London's "trendy Dalston", Simpson provided photography for this month's Fetish. "First and foremost, a piece of WIRED technology needs an edge – something special about it," he says. "My favourite things are those that just work, but it's always nice when they look cool, too. Take the McLaren MP4-12C. I'd like to shoot one, then have a go driving it around."

Spencer Lowell

Lowell photographed Michael Acton Smith – the maestro of all things Moshi – for our Startup special. "When you walk into the Mind Candy HQ, you see a sign that reads 'work hard and be nice to people' – that's totally how Smith comes across," says Lowell. "I portrayed him as being a friendly, enchanting character, so it would resonate with his work."

Jonah Lehrer

In a WIRED exclusive, Lehrer reveals his tips for being more creative. "Creativity requires a lot of trade-offs," he says. "Group collaborations are more effective when people engage in dissent – feelings are going to get hurt." So, how does he get inspired? "Long walks – but I leave my phone behind. I can't daydream properly if I'm always checking my email…"

Alex Bateman

Bateman suggests that his fellow scientists use Wikipedia as a way to engage the public with their research – and to harness the power of the crowd. "However, scientists can come into conflict with Wikipedians who know all about the posting rules, but not about the subject matter," he says. "Getting these two groups to play nicely can be challenging."

Making WIRED

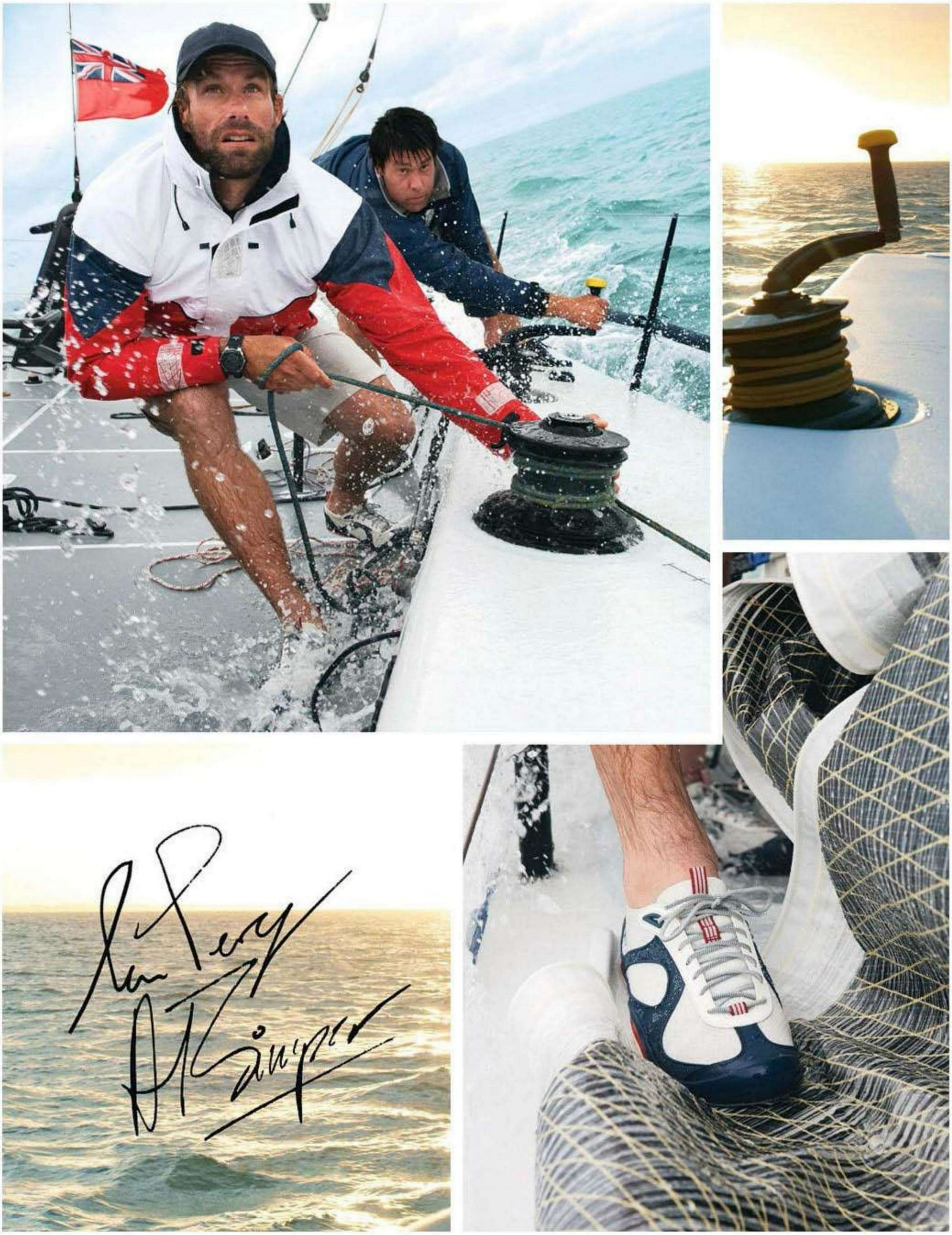
An urbex state of mind

Lana Sator, "Sneak inside a rocket factory", p45: "There are lots of urbex fans in Russia because we have so many abandoned industrial places. As well as taking photographs, we're learning the history of these industries. I have a lot of friends involved in the urbex culture and state of mind. We live, we work – and at the weekends we look for something to explore."

Photographer's best friend

Charlie Surbey, "Lassie 2.0 transmits home", p25: "The saying, 'Never work with children or animals', couldn't have been further off the mark when it came to photographing Byron the rescue dog. I had six flashes going off from all directions, but he remained calm. Byron's super-cool temperament is due to his dangerous day job – he's definitely man's best friend."

PHOTOGRAPHY: LANA SATOR/CATERS NEWS



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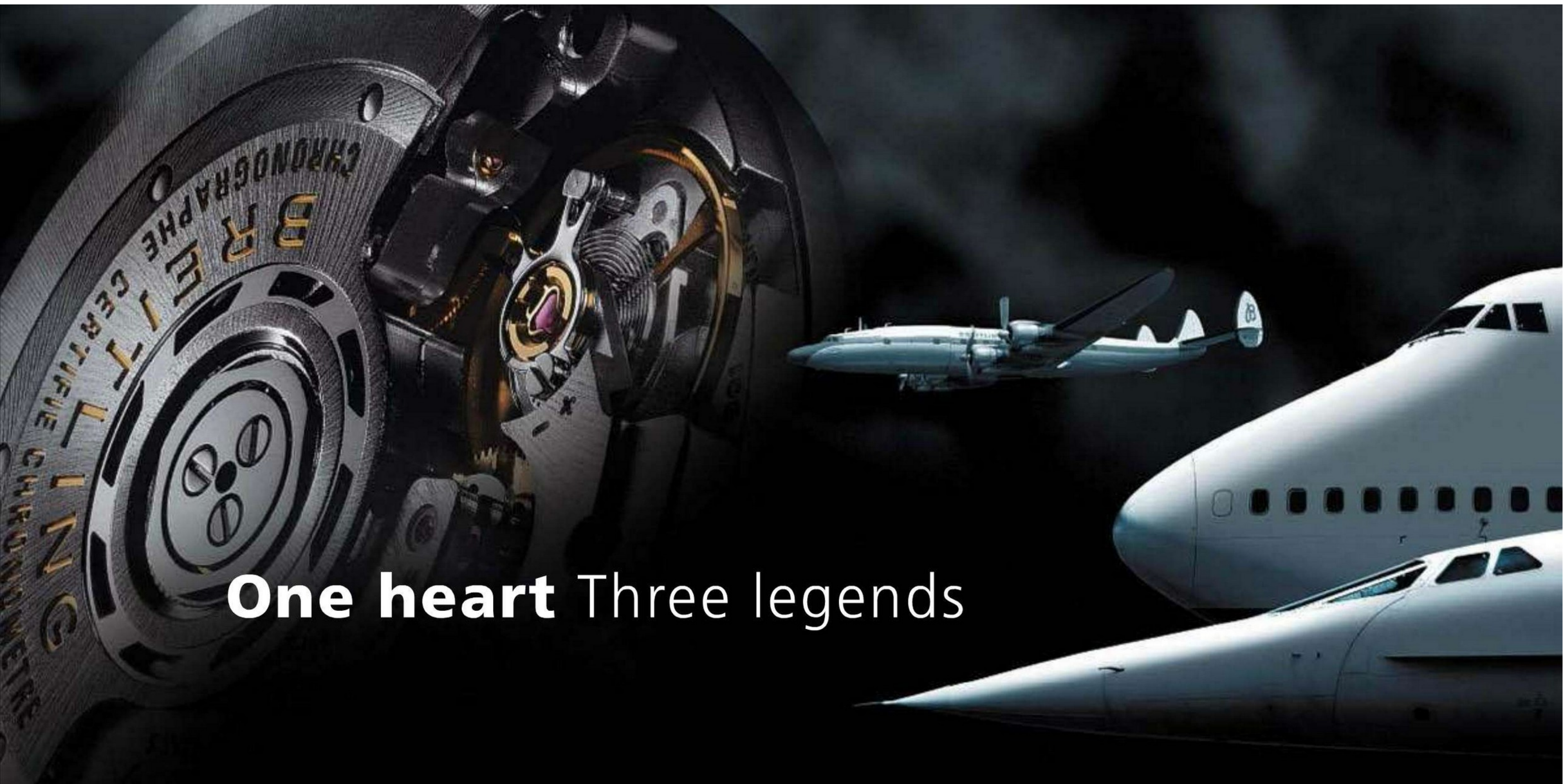

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FROM THE EDITOR

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WIRED is three years old this issue – yet as we grow, we still aim to retain the nimble, adaptive culture of a startup. Whether we're launching apps, planning events or building a consulting arm of the publishing business, we know we'll fail in our mission at the first sign of complacency, of a lack of fresh thinking, of any dilution in the quality of the "product" you're holding in your hands.

Right: Logging on at Mind Candy's London office

But… well, as a Condé Nast magazine, we're hardly a *real* startup. Sure, we think we've built a team around world-class talent; and obviously, we're iterating in constant beta as we respond to your feedback. But we don't have to raise capital in the marketplace, or build revenue around an unproven model. We're not taking the unfathomably big risks that have led the founders of Skype, of Spotify, of Square to take on established industries and improve all our lives by disrupting them.

So this month, we have chosen to celebrate the startup world – and to encourage you to join it. Ambitious entrepreneurs such as Mind Candy's Michael Acton Smith and Skype's Niklas Zennström are key to reviving the wider economy, so we've devoted a 16-page section to sharing their detailed advice – on everything from how to recruit developers to how to build a global online brand. We've also pinned down some of Europe's most influential investors to discover what they're looking for and how to pitch them effectively – with additional and very concrete advice from experts in marketing, recruitment, revenue-generating and buzz-building. You'll find even more guidance at our special online Startup Guide at wired.co.uk/howtostartup – again, all written by the founders and investors themselves. Let's hope they inspire you to take the plunge yourself.

Elsewhere in the issue, we revisit little-seen places in Britain where science leapt ahead, from the lab where DNA was first understood to the road that inspired Catseyes. Many of these suggestions came via Twitter after we asked *@WiredUK* followers for ideas. Thanks for your excellent contributions – and apologies to the Foreign Secretary, William Hague, who tweeted for Bletchley Park. We couldn't fit it in, but hey, thanks for the follow…

David Rowan, Editor

David Rowan

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- DMA Magazine of the Year 2011
- DMA Technology Magazine of the Year 2011
- BSME Art Director of the Year, Consumer 2011
- D&AD Award: Entire Magazine 2011
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- BSME Launch of the Year 2009

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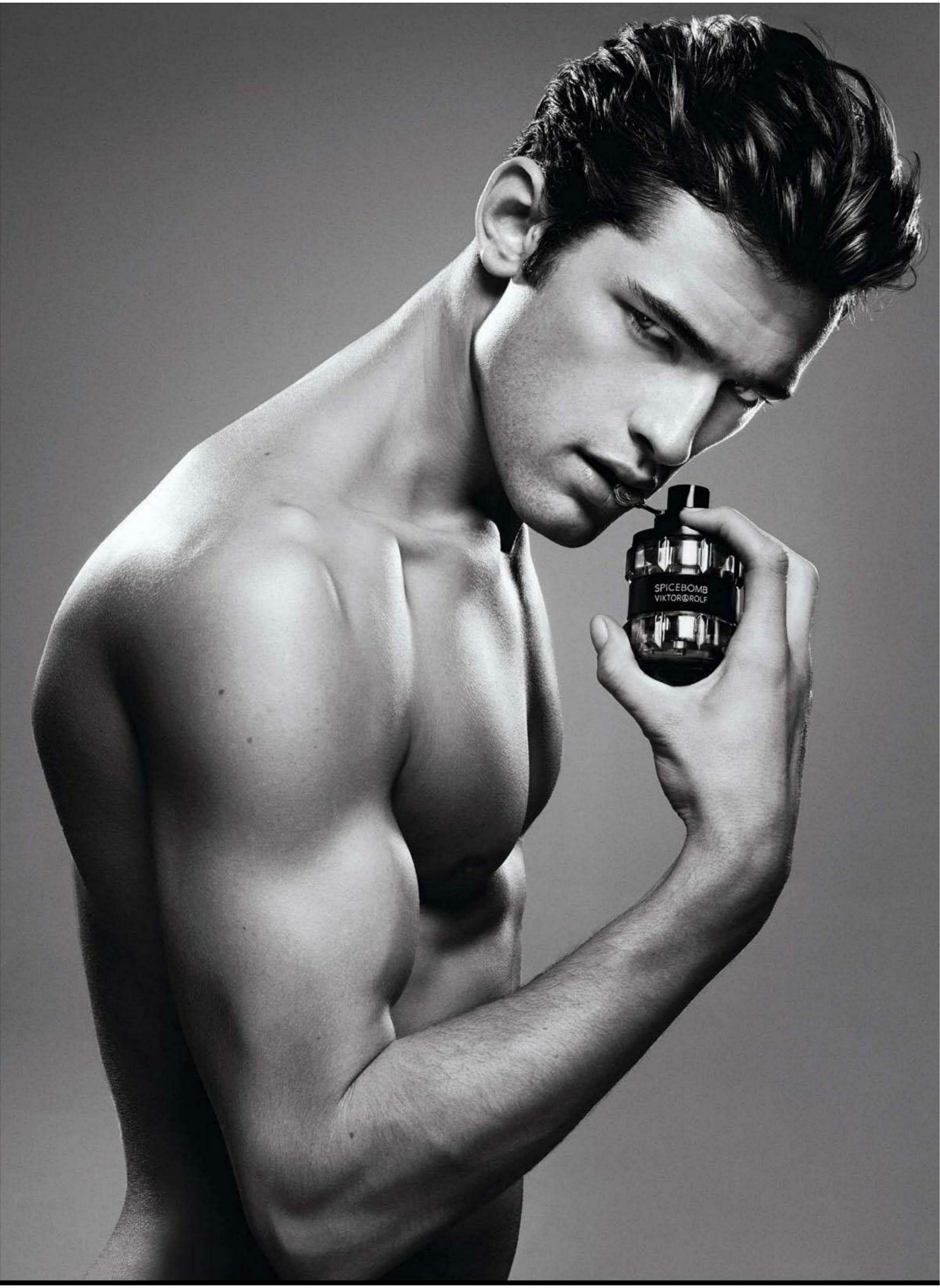
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- RECYCLING WEAPONS
- STILLFLY DRONE
- URBEX PHOTOGRAPHY

EDITED BY **JOÃO MEDEIROS**

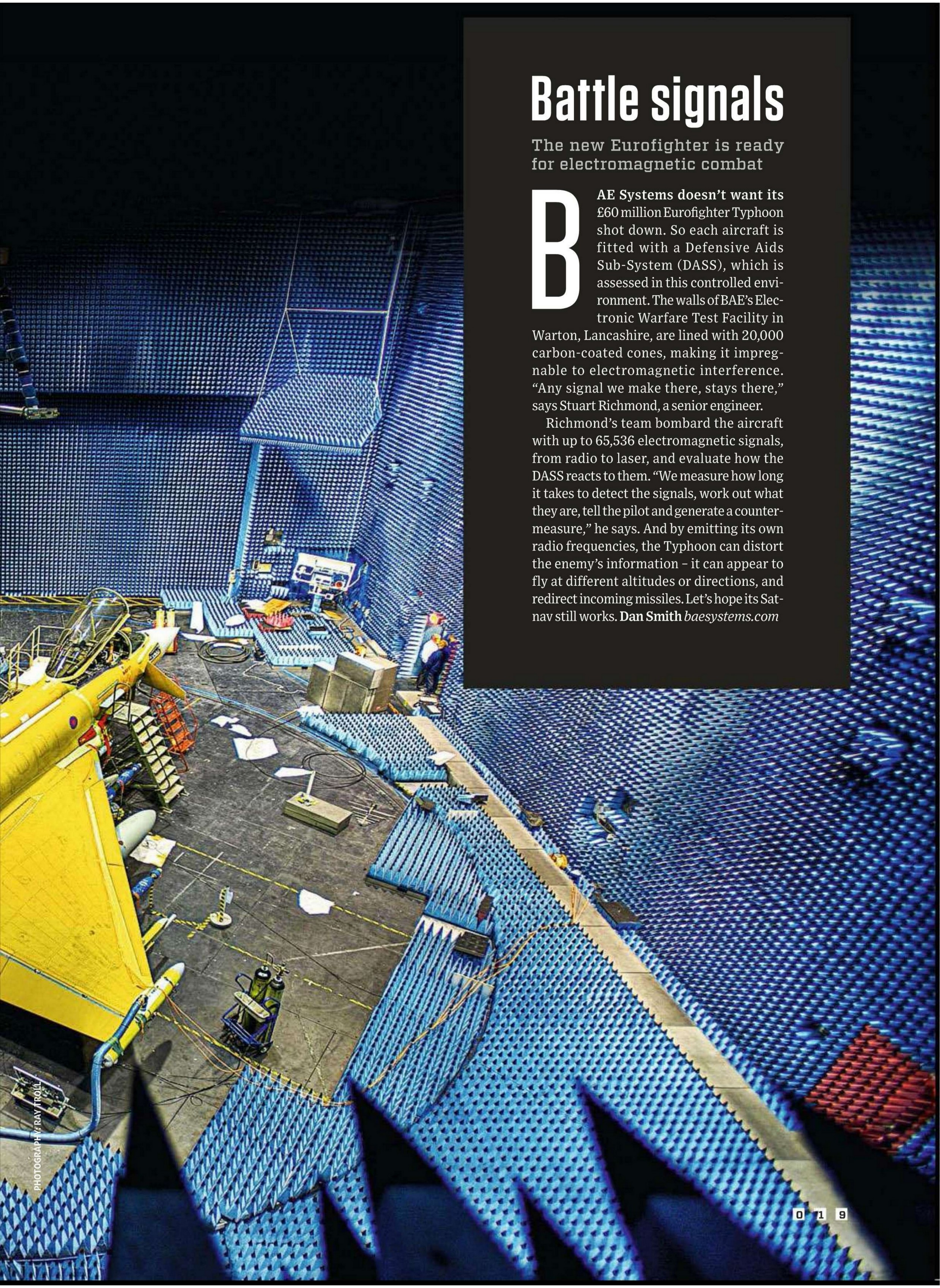
CREDIT TO GO IN HERE

Battle signals

The new Eurofighter is ready for electromagnetic combat

BAE Systems doesn't want its £60 million Eurofighter Typhoon shot down. So each aircraft is fitted with a Defensive Aids Sub-System (DASS), which is assessed in this controlled environment. The walls of BAE's Electronic Warfare Test Facility in Warton, Lancashire, are lined with 20,000 carbon-coated cones, making it impregnable to electromagnetic interference. "Any signal we make there, stays there," says Stuart Richmond, a senior engineer.

Richmond's team bombard the aircraft with up to 65,536 electromagnetic signals, from radio to laser, and evaluate how the DASS reacts to them. "We measure how long it takes to detect the signals, work out what they are, tell the pilot and generate a countermeasure," he says. And by emitting its own radio frequencies, the Typhoon can distort the enemy's information – it can appear to fly at different altitudes or directions, and redirect incoming missiles. Let's hope its Satnav still works. **Dan Smith** *baesystems.com*



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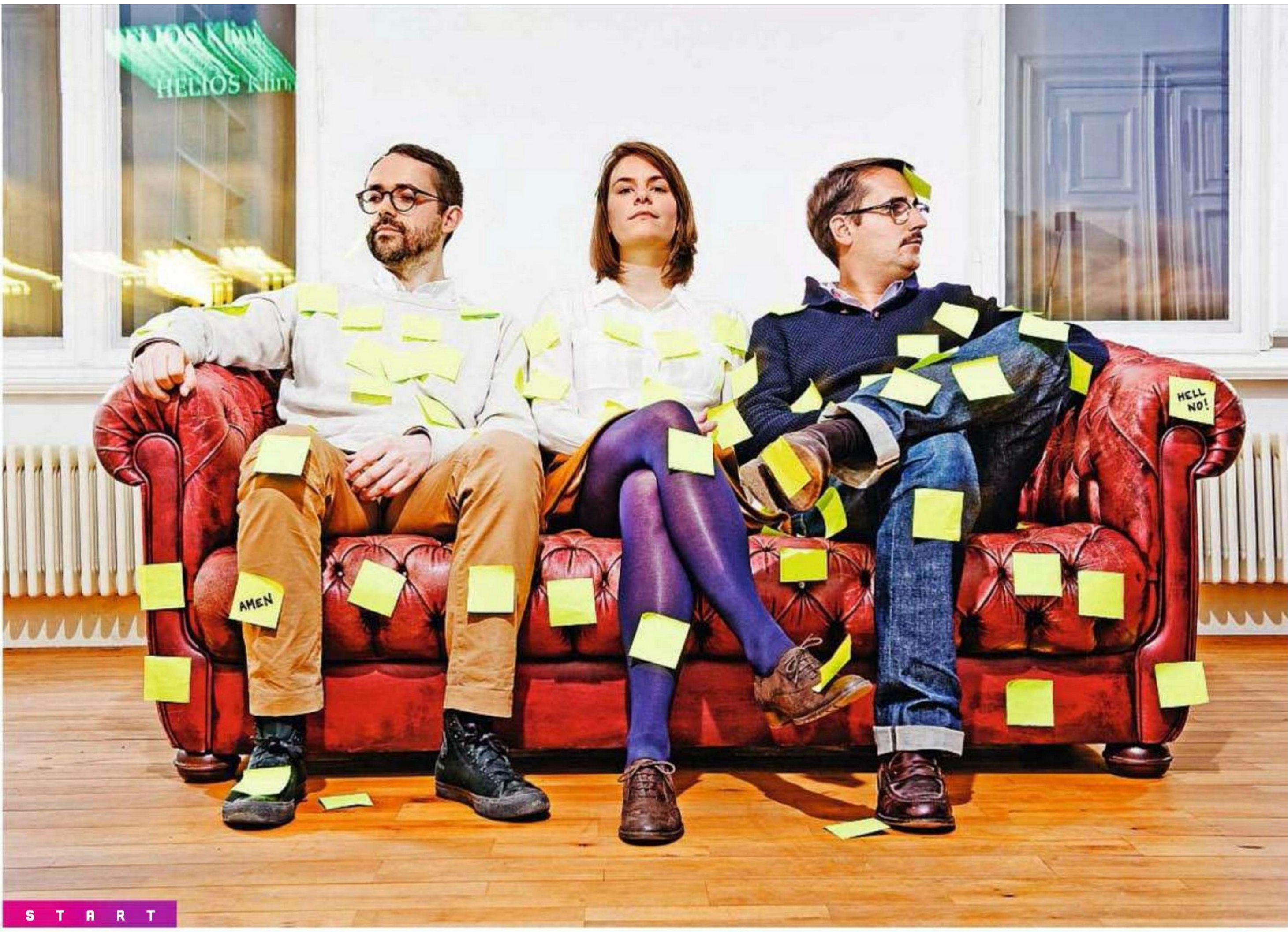


Post your opinion and see if it sticks

Finally: a means of quantifying the world's views on life, the universe and burritos

Need to get a viewpoint across? Your prayers have been answered. *Amen* is an iOS app intended to rank every place, person or thing, using heated arguments over what's best and worst. Open the app and let loose your opinions – "WIRED is the best magazine ever"; "Ryanair is the worst airline ever" – in absolute statements, then follow your friends. Agree ("Amen") to vote items up, or disagree ("Hell no!") and offer an alternative to further the debate.

"People say the world isn't black and white," says Felix Petersen (*above, right*), Amen CEO and cofounder, who sold his startup Plazes to Nokia in 2008. "But if you have enough absolute statements about something, and you add them all up, you get something more complex." Out of the fray, consensus soon emerges. Navigate the app to find objects ranked by the most votes in a category, or find all the opinions tagged to any item. Everything's covered, from songs to burritos to books. The Berlin-based company launched last October after raising $2 million (£1.2 million), whilst still in private beta, in a seed-funding round led by Index Ventures.

Names: FLORIAN WEBER, CAITLIN WINNER AND FELIX PETERSEN
Occupation: FOUNDERS, AMEN
Location: BERLIN
Need to know: THEY LOG YOUR POINTS OF VIEW AND TURN THEM INTO SOCIALLY CURATED LISTS

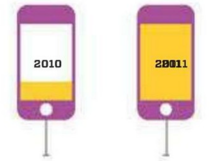
Petersen, 35, and cofounders Caitlin Winner (*centre*) and Florian Weber (*left*), wanted to build a platform for ranking things while avoiding the boredom inherent in list-making by aggregating opinions into socially curated lists. "We thought, how could we make an opinion a standalone thing, that you could interact with in the same way that you could with a photo?" says Winner, 28.

By restricting the structure ("X" is the best/worst "Y"), *Amen* can interpret semantics and put the data to use. Future updates will embed song tracks within the list of the best songs, or include maps and directions alongside a list of the best restaurants and bars. Beyond the iOS app (and mobile web app for other platforms), Petersen says a reference site is being built from this data, where the opportunities for cataloguing *everything*, alongside the world's opinions of it, are limitless. Amen to that.

Jeremy Kingsley *getamen.com*

THE WIRED INDEX

Total consumer spend on mobile phones in the UK. *For sources, see Colophon (p154)*



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PHOTOGRAPHY: TIMMO SCHREIBER

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Walk on the wild side

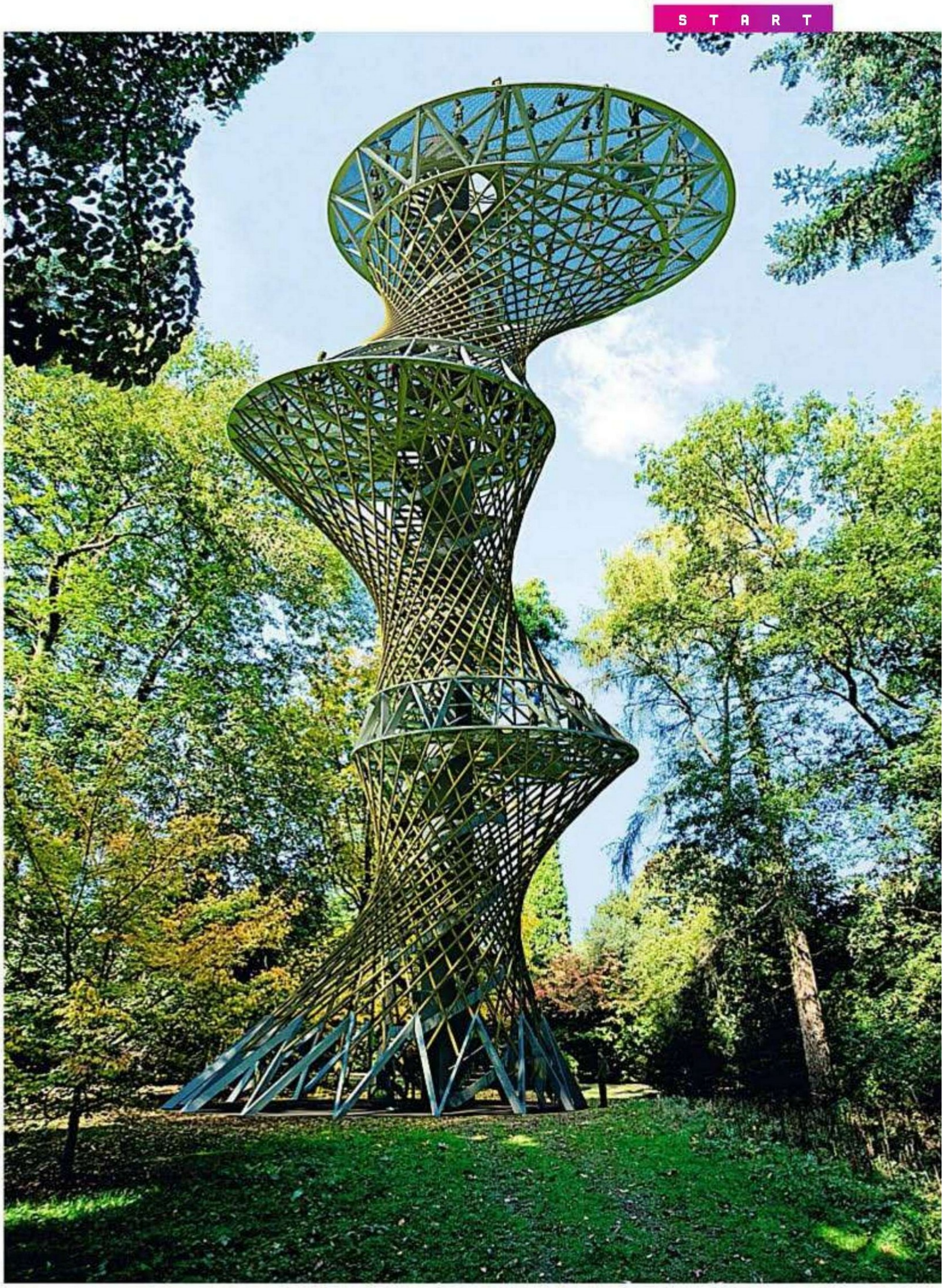
The architects behind Kew Gardens' walkway and the London Eye are building again – in the rainforest

This skew-whiff structure isn't the world's largest butterfly net, but the design for a proposed 40-metre-high rainforest observation tower. The bamboo-built construction will be part of the Amazon Science Centre, a £6.4 million conservation base to be housed in the isolated Roraima province in northeastern Brazil. London architects Marks Barfield, designer of the London Eye and Kew Gardens' Treetop Walkway, began building last year.

"We want to create a science centre that will appeal to scientists, ecologists and environmentalists, as well as to visitors," says managing director David Marks. "And for them to experience the remote jungle, first-hand. Every acre has about 300 species of trees."

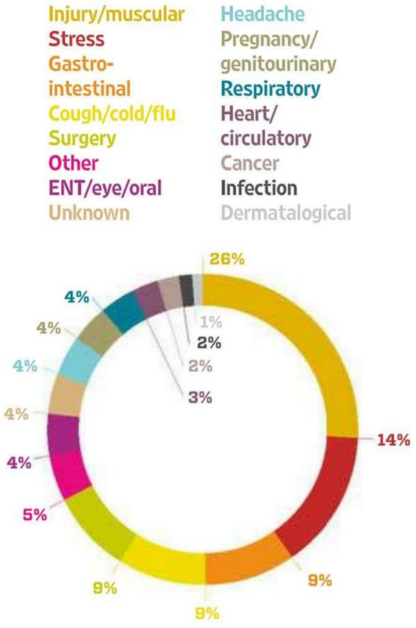
The centre has three distinct elements: a complex of buildings that will function as research labs and staff accommodation; a multi-platform spiral observation tower for tourists; and an elevated 10km-long treetop walkway, suspended in the canopy.

Not surprisingly, building on this scale in the remote jungle brings challenges. "It's very harsh, humid and corrosive," says Marks. "And it's subject to flooding, beetle infestation, damage from falling trees and wild animals." His solution is to use as many natural materials growing on or near the site as possible, such as Colombian bamboo, rope, palm mats and recycled rubber. The centre, which is partly funded by the Amazon Charitable Trust, should be operational by 2014. Let's hope you can upgrade to Champagne capsules. **Madhumita Venkataramanan** *www.marksbarfield.com*



THE WIRED INDEX

Days lost to sickness per UK employee in 2010 by reason, according to the FirstCare Absence Management System



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FORM FOLLOWS CREATIVITY.

The new award-winning Lumix GX1 was created for the truly demanding photographer. Its large light-receiving sensor precisely captures even the finest details, and renders images with breathtakingly high quality. Its intuitive handling directly relays the user's intent, while the elegant design makes it a joy to own – bringing new and exciting discoveries with almost every shot.

Learn more about the performance of the Lumix GX1 at www.panasonic.co.uk/GX1

What Digital Camera GOLD AWARD
What Digital Camera, December 2011.

DIGITAL PHOTO GOLD AWARD
Digital Photo, February 2012.

Lumix GX1 available in black and silver, and with various lens configurations.
Additional lenses sold separately. See dealer for details.

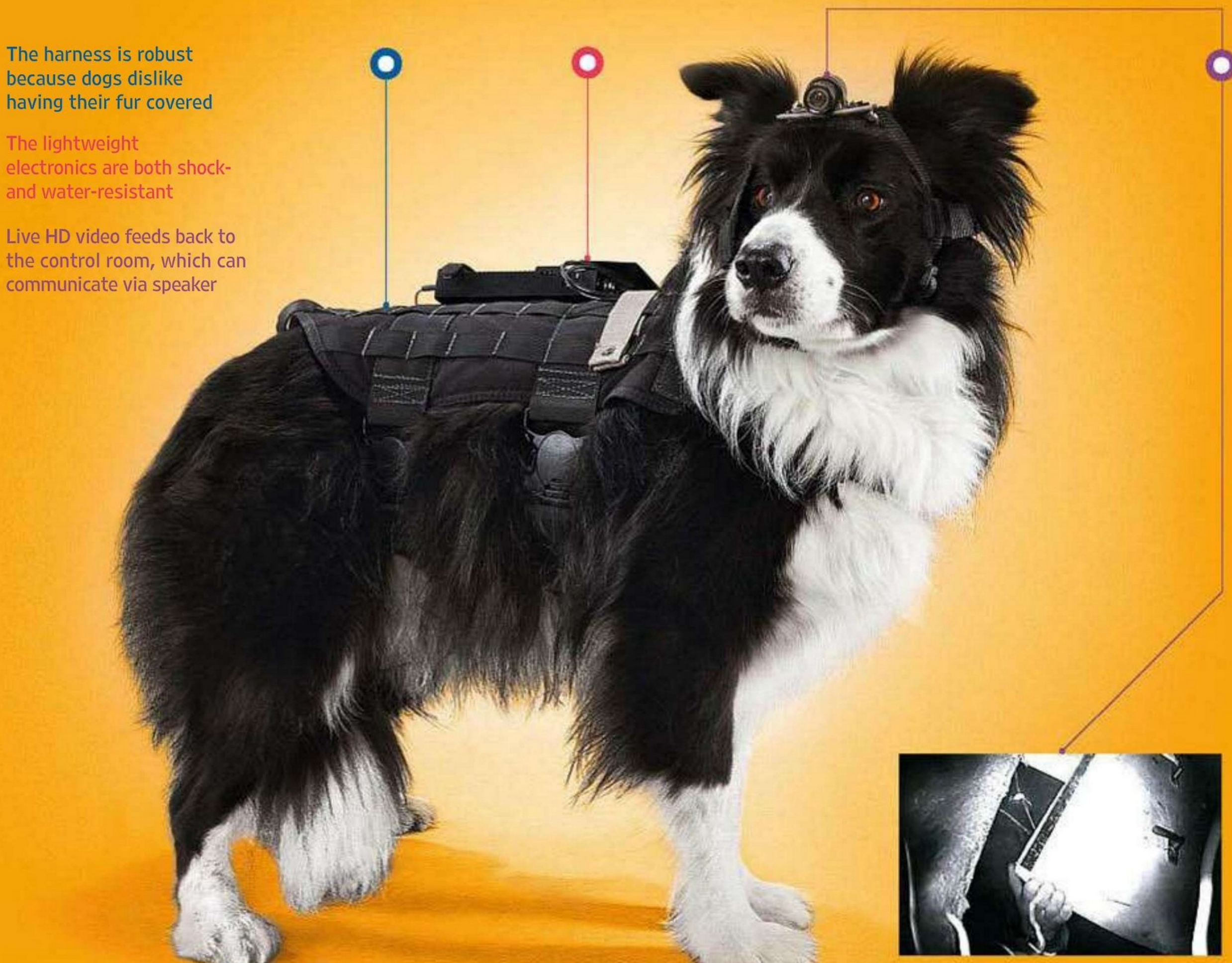
Lassie 2.0 transmits home

Searching for survivors? You need a radio-enabled GPS dogcam

Natural instincts and unwavering enthusiasm make dogs the ideal urban search-and-rescue workers. And kitted out with Portable All-terrain Wireless System (Paws), an application developed by UK wireless-tech firm Wood & Douglas, this hound no longer even needs to wait for his handler to catch up.

With his head-mounted camera, GPS module and two-way radio, Byron the dog (*pictured*) can pinpoint the location of any survivors he finds on a digital map in the control room, while streaming HD video to the rescue team. They can then reassure and question victims over the radio. Wi-Fi and radio waves are confounded by concrete, but the multiplexing transfer system (which can transmit more than one signal over a line) used by Paws isn't affected by this. "The only thing we haven't done," says Grant Norton of Wood & Douglas, "is bomb disposal." **Jim Hill** *woodanddouglas.co.uk*

iPad extra!
Download the WIRED app to see a dogcam view of the Paws system in action


The harness is robust because dogs dislike having their fur covered
The lightweight electronics are both shock- and water-resistant
Live HD video feeds back to the control room, which can communicate via speaker

PHOTOGRAPHY: CHARLIE SURBEY; BYRON; REX; JC LENDEMER

THE SCIENCE OF CELEBRITY

Celebrity culture has permeated even the loftiest heights of academia: when biologists or astronomers discover something new, the International Code of Zoological Nomenclature and the Minor Planet Center lets them name it as they please. Can we request that the next potentially Earth-destroying asteroid found be named *TOWIE*? **MV**

Mick Jagger
Aegrotocatellus jaggeri
A trilobite species
(Adrain and Edgecombe, 1995)

Beyoncé
Scaptia (Plinthina) beyonceae
A horse fly
(Bryan Lessard, CSIRO, 2012)

Barack Obama
Caloplaca obamae
An orange lichen
(Kerry Knudsen, Santa Rosa Island, California, 2007)

Meg Ryan
8353 megryan
An asteroid
(EW Elst, European Southern Observatory, 1989)

Angelina Jolie
Aptostichus angelinajolieae
A trapdoor spider
(Amy Stockman, Jason Bond, 2008)

INFO PORN

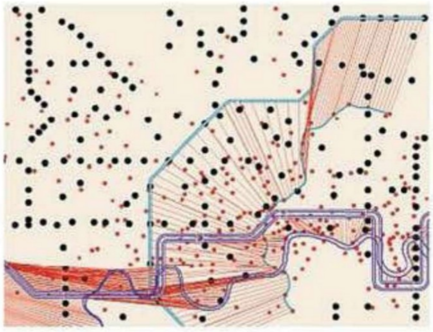
London as seen from the Tube

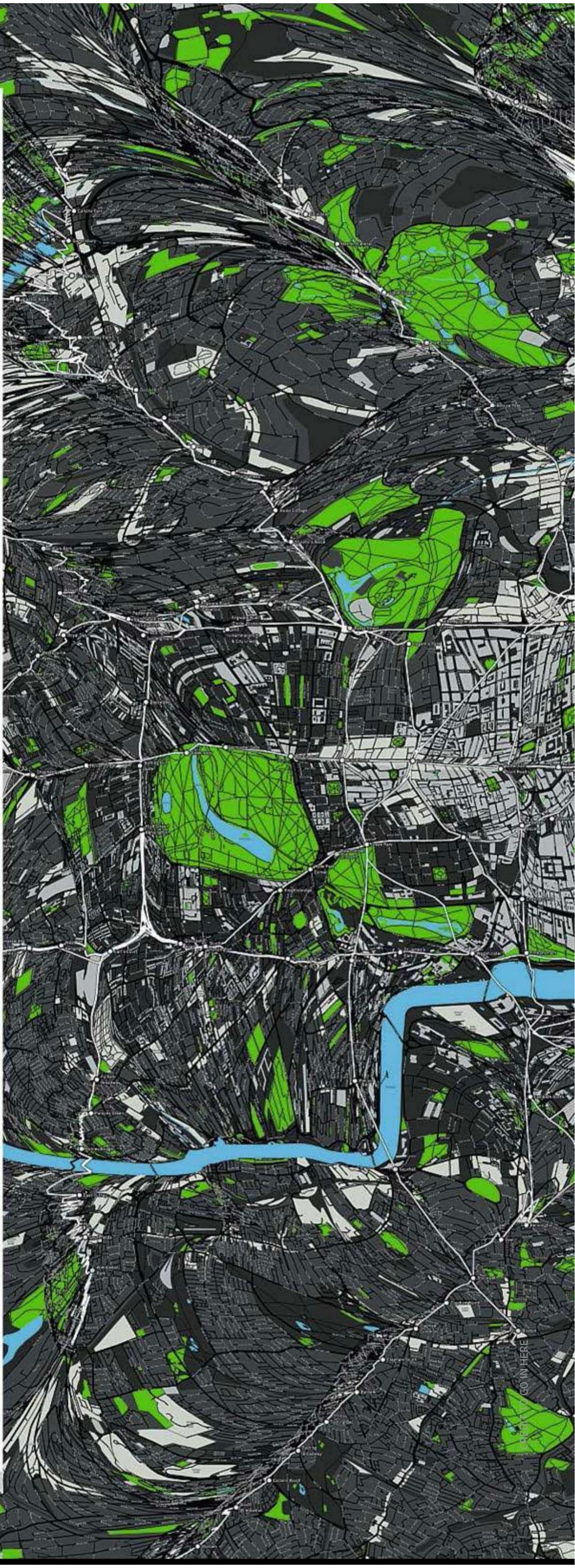
How Harry Beck's map distorts the physical capital

Recognise the city? Students Benedikt Groß and Bertrand Clerc, interaction designers at the Royal College of Art in Kensington, created this map to show how they believe Londoners perceive the city – in terms of Harry Beck's 1931 London Underground map. "We're visualising the imaginary, mental map Tube users have of London," says Groß. "For many, Beck's map is more useful than the actual geography."

They call their project Metrography. It uses 1,865,565 data points from OpenStreetMap and merges them with TfL's Tube map, which includes railway stations and the Thames. The latitude and longitude of each point was then recalculated, keeping the positions of the Thames and stations as fixed references. Metrography wasn't designed for navigation, but Groß, 32, and Clerc, 30, believe representational guides such as this could become popular. "In future an accurate map might be less important than an abstract map," says Clerc. "And maybe we've started that process." **Dan Smith** *looksgood.de*

The duo also mapped reality versus Beck using dots: the black ones are Beck's (the Victoria line is also shown) and the red ones are the true locations





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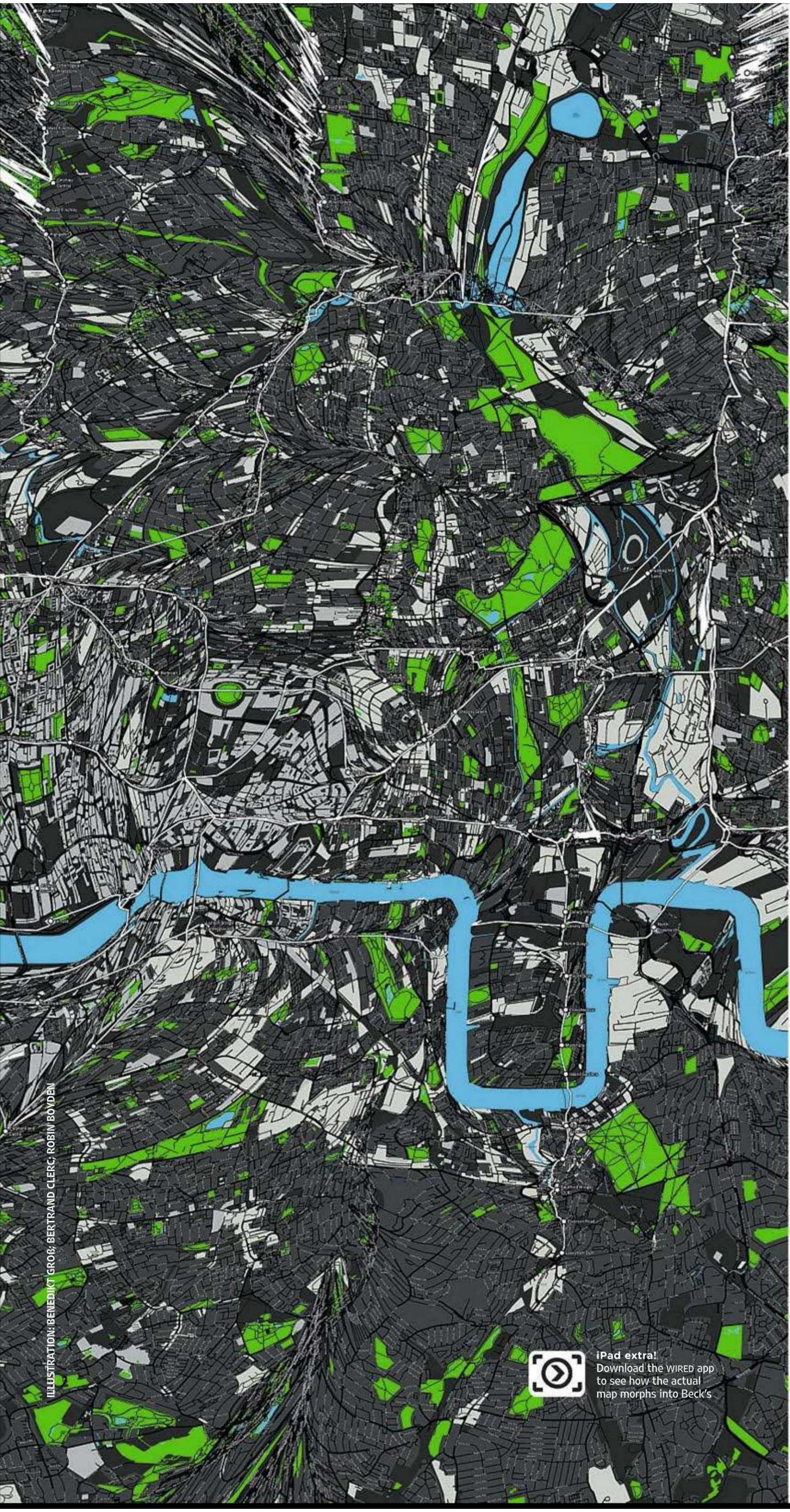


iPad extra!
Download the WIRED app to see how the actual map morphs into Beck's

ILLUSTRATION: BENEDIKT GROß; BERTRAND CLERC; ROBIN BOYDEN

JARGON WATCH

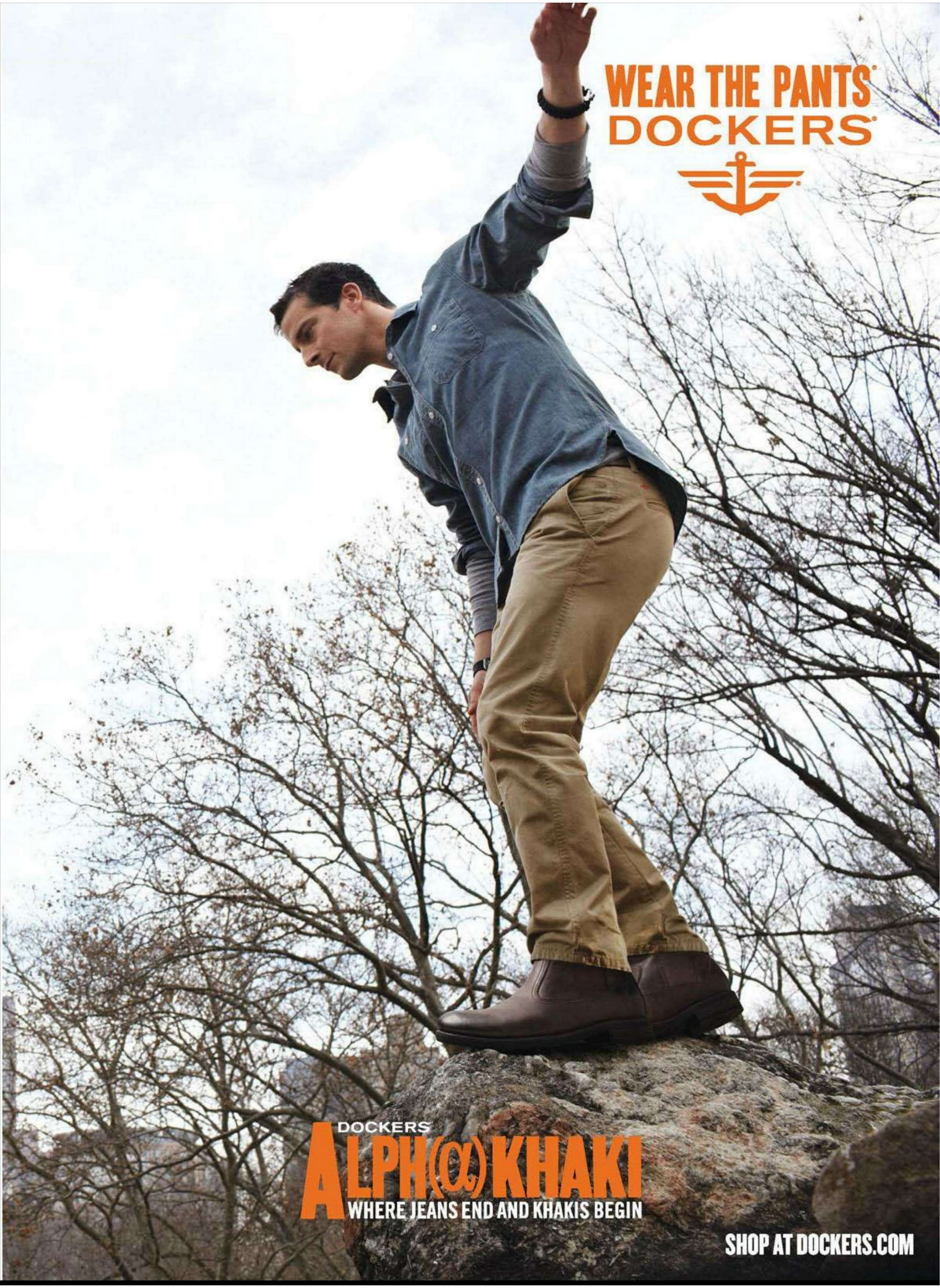
VB6
n. A person who eats a vegan diet only before 6pm. See also: *pescetarian* (a vegetarian who eats fish), *pollotarian* (a veggie who eats chicken), and *flexitarian* (a veggie who eats meat or fish occasionally).

Physible
n. A digital file containing instructions that enable a 3D printer to create a physical object. The Pirate Bay recently added a "Physibles" category. (The word is an odd blend of "physical" and "feasible".)

Eurogeddon
n. A European crisis, especially one caused by economic problems. With panicked investors fleeing government bonds, and with political leaders unable to staunch the wounds, could the euro fail or the EU fall apart?

Showroom
v. To visit a retailer to view and research a product and then purchase the product for less online. Showroomers use shops to get a feel for the product and discuss it with a member of staff, then leave. **Paul McFedries**

The Alpha Khaki as worn by Bear Grylls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A HACK A DAY LETS YOU TOAST, PHONE AND PLAY

Thanks to the Hack a Day website we now know how to install pneumatic *Star Trek*-style doors and create an orchestra out of old floppy drives. "It is becoming much more common to find some altered piece of electronics in the average home," says Caleb Kraft, senior editor of LA-based hackaday.com. Here are five of its most imaginative ideas. Leila Johnston ***hackaday.com***

VHS toaster

Inspired by an episode of *The Young Ones*, one hacker fitted a toaster inside the tape slot of an old VHS player. It also scorches "VHS" on each piece of toast it produces – a nice touch, though the maker doesn't recommend leaving it unattended.

Road sign hacking

Once hackers worked out that most roadside construction dot-matrix displays use the same default password and have a programmable keypad inside, a world of (usually zombie-related) mischief opened up. A word of warning: this is illegal.

A pulsed laser pistol

Patrick Priebe has created a *Star Wars*-style laser gun. Adapting a Q-switched Nd:YAG laser (used for industrial metal-cutting), it relies on a battery charging a capacitor bank with 350-400v. It looks fun, but it can blast through a razor blade.

Kinect hacking contest

Johnny Chung Lee, a former Microsoft employee who worked on the Kinect, offered a reward to the first hacker who open-sourced the Kinect driver. The honour would go to Héctor Martin, founder of openkinect.org. Microsoft hasn't sued (yet).

The first iPhone jailbreak

As soon as the iPhone launched, hackers raced to crack Apple's single-vendor lock. George Hotz was first: forcing his way inside the case, his physical hack connected two traces on the motherboard, rendering the firmware protection useless.

PHOTOGRAPHY: GREGG SEGAL. ILLUSTRATION: PHIL WRIGGLESWORTH

File transfer protagonist

Dropbox's boss plans to outplay Apple – with simplicity

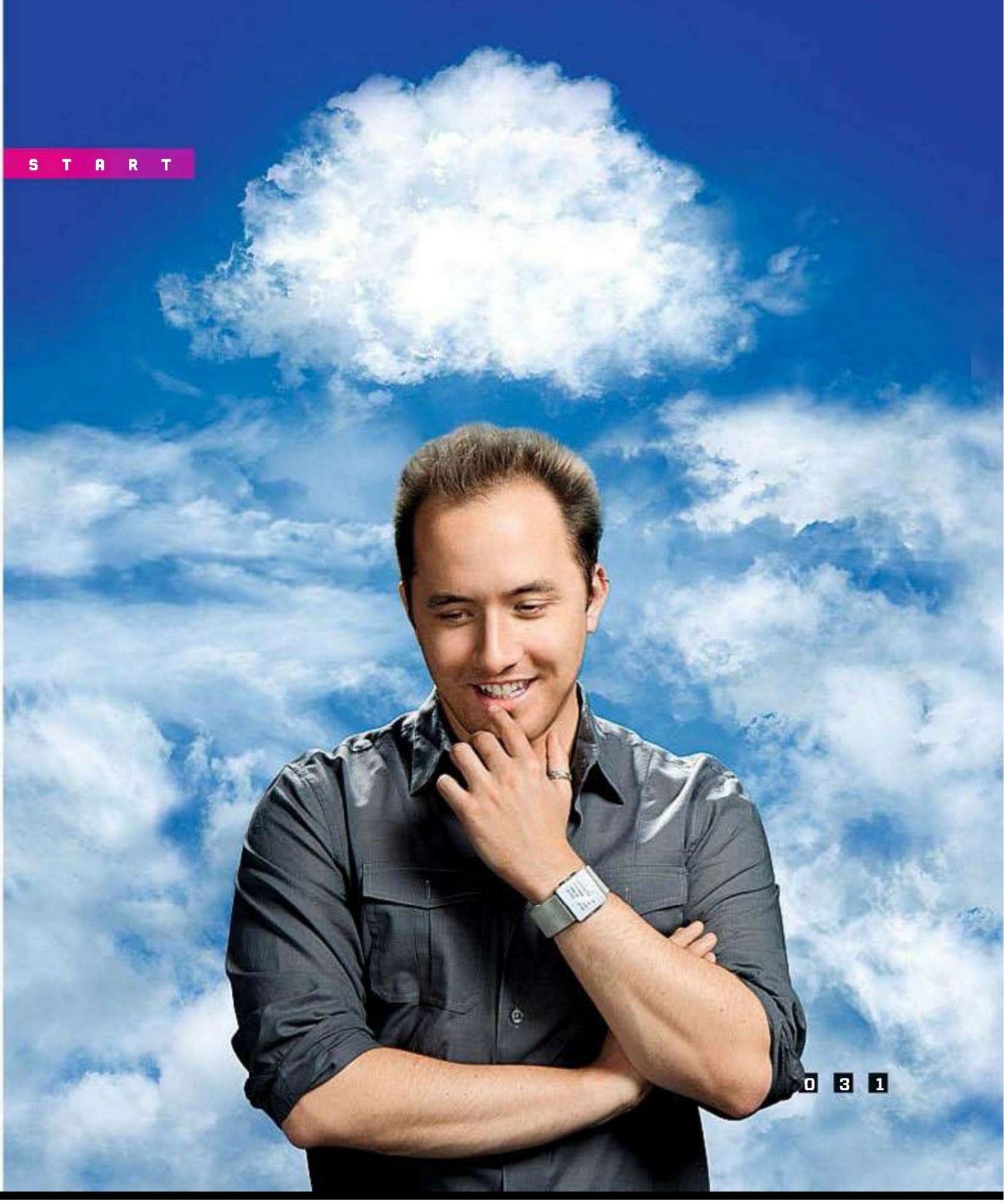
Drew Houston has $250 million (£150m) in the bank – so he's gone shopping. His cloud-storage service Dropbox was recently valued at $4 billion after funding by Index, Sequoia and Greylock – so in February, it began spending. The San Francisco firm's acquisition of Cove, led by two former Facebook engineers, is the start of a new phase for the 100-person firm, which aims to treble its team by 2013. "We didn't need the money for anything imminent," Houston says. "But opportunities came along for an acquisition."

The 29-year-old's mission is to "build a fabric that ties together all your devices, services and apps". So, with cofounder Arash Ferdowsi, he's been looking to strengthen a service that has 50 million users (another's added every second) saving 325 million files a day. A deal with HTC will integrate Dropbox into Android phones.

Houston had the idea for Dropbox after forgetting his USB drive on a bus from his MIT course in Boston to New York. He started writing code in the bus station, later pitched Dropbox at Y-Combinator, and launched in 2008. Two years later, Steve Jobs called. "He told us, 'you guys are a feature, not a product'." Later, at Apple's iCloud launch, "it was made clear that they were aggressively going after this space".

So how will Dropbox compete with the Apples and the Googles as they commodify storage? "My mum has her music in iTunes and wants to listen on her Android phone, but the things won't talk to each other," he says. "People want everything to be compatible. That's the problem we solve. We keep the experience simple." **DR** *dropbox.com*

Name: DREW HOUSTON
Occupation: COFOUNDER AND CEO OF DROPBOX
Location: SAN FRANCISCO, US
Need to know: HE'S TURNING CLOUD STORAGE INTO A BRIDGE BETWEEN DEVICES



Interplanetary ice diver

After revealing the secrets of Earth's seas, Endurance is heading to Jupiter

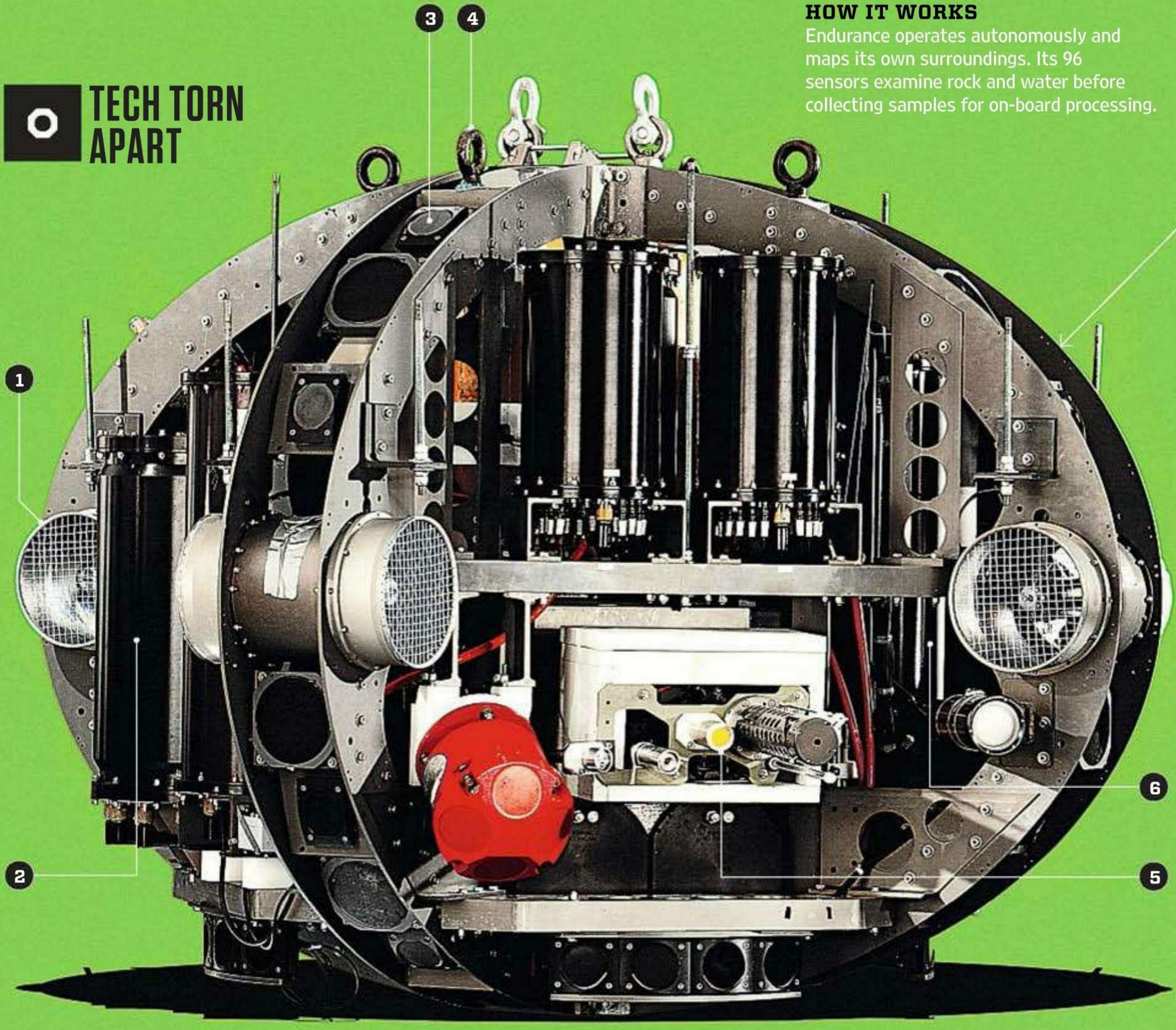
Stone Aerospace's autonomous underwater vehicles (AUVs) have explored the frontiers of Earth's deep-sea worlds. In 2007, the Texas-based company's DepthX craft explored the Zacatón hydrothermal spring complex in northern Mexico. The following year, DepthX's smaller variant, the Endurance, travelled beneath Antarctica's ice sheets. Its next stop: Europa. Stone Aerospace is working with Nasa to send an AUV to explore the Jupiter moon's frozen seas within the next 20 years. Europa is thought to host vast saltwater oceans beneath its surface – a likely candidate for microbial life. Here's how its mission will go down. **Jeremy Kingsley** *stoneaerospace.com*

START

HOW IT WORKS

Endurance operates autonomously and maps its own surroundings. Its 96 sensors examine rock and water before collecting samples for on-board processing.

TECH TORN APART



1. SIX THRUSTERS
Four horizontal and two vertical thrusters enable movement in every direction. Only half are needed – the extras are built-in redundancy. Combined, they create 1,400N of thrust.

2. PRIMARY COMPUTERS
Endurance has 45 computer processors for navigation and data-gathering. Video and still images are also processed on-board to identify signs of potential life forms for sampling.

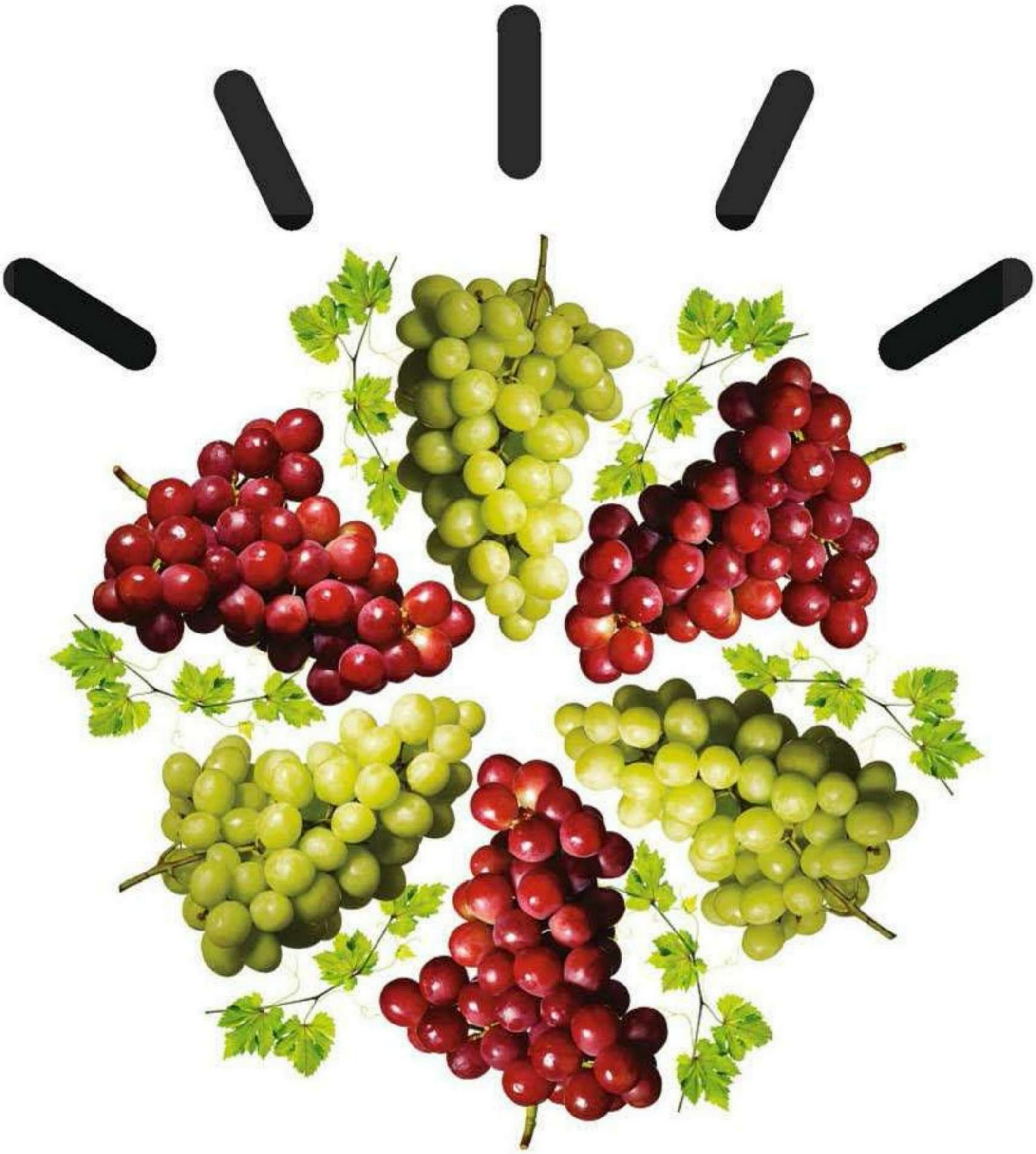
3. SONAR SENSORS
Two racks of 56 sonar sensors can find objects up to 300 metres away. Called simultaneous localisation and mapping (SLAM), this helps to build a topographical map.

4. SATELLITE CONNECTIVITY
After gathering samples on Europa, the submersible will return to the ocean's surface to transmit data back to Earth, relaying the transmission via an orbiting satellite.

5. SONDE PACKAGE
This package of instruments can be lowered from the craft, attached by an ethernet and power cable. Descending 100 metres, it can sample water chemistry and record images.

6. BUOYANCY ENGINES
Variable buoyancy engines (VBEs) hold the craft in position within a 5cm horizontal and 1cm vertical margin by gauging water pressure, temperature and salinity.

PHOTOGRAPHY: JOHN B CARNETT



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Turning Africa's weapons into bling

How to phase out AK-47s: turn them into high-end jewellery

There are an estimated 20 million assault rifles in Africa, making the continent a perilous place to live – and invest – in. So one social enterprise, Fonderie 47, is setting out to reduce that number by transforming the AK-47's recyclable materials into jewellery.

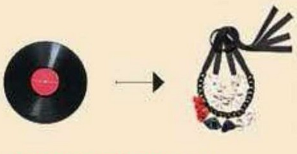
Founded in November 2011 by Peter Thum, a social entrepreneur and the force behind Ethos Water, and John Zapolski, a designer and business adviser, New York-based Fonderie 47 buys decommissioned AK-47s in the Democratic Republic of Congo and melts them down into high-quality steel. This, along with recycled gold and semi-precious stones, is turned into cufflinks, rings and earrings by high-end jewellery designers Roland Iten and Philip Grangi. The jewellery is sold for between $25,000 (£15,000), for a ring, and $150,000, for a pair of earrings. The money is funnelled back to the DRC via UK charity Mines Advisory Group (MAG), where it is used to buy up and destroy more AK-47s. Thum says a pair of cufflinks ($35,000) funds the purchase and destruction of 100 rifles.

Fonderie 47 won't say how much money it has raised so far, but MAG says it has destroyed 7,000 guns thanks to jewellery sales. Nicely targeted. **DB** *fonderie47.com*

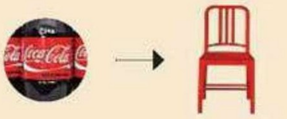
RIFLE RECYCLING
Once the AK-47s have been put beyond use – slicing them into chunks usually does the trick – the metal parts are melted down into ingots, ready to be reworked.

CLIPS TO CLIP-ONS
Roland Iten's mechanical cufflinks contain metal from AK-47s, and are limited to 20 pairs. They can also be transformed – the two pieces combine to create a bracelet.

...AND OTHER WAYS UPCYCLING IS GOING UPSCALE



OBSOLETE LPs TO FASHION JEWELLERY
Marni designer Consuela Castiglioni has launched a range of necklaces, earrings and bracelets made using vinyl records – the grooves are a desirable feature. *marni.com*



OLD COKE-BOTTLES TO CLASSIC CHAIRS
Commissioned by Coca-Cola and developed by Emeco and BASF, the Emeco 111 Navy Chair remakes a design classic, built with 111 recycled plastic Coke bottles. *emecowithcoke.com*

USED FIRE-HOSES TO BIJOU BAGS
Elvis & Kresse makes high-end bags, belts and accessories from reclaimed waste including old fire-hoses, coffee sacks, parachute silk and sail cloth. *fire-hose.co.uk*

WASTE AND SCRAPS TO ARTISAN *OBJET*
Hermès has created Petit h – around 2,000 "objets" made from rejects and leftovers found on its workshops' floors, such as coat hooks made from old teapot spouts. *hermes.com*

PHOTOGRAPHY: ALAMY; REX; ISTOCK

Screen images simulated. ©2012 Samsung Electronics Co. Ltd.

THE BIG QUESTION

"What vaccines will we invent in the next decade?"

Paul Offit
Inventor, the rotavirus vaccine

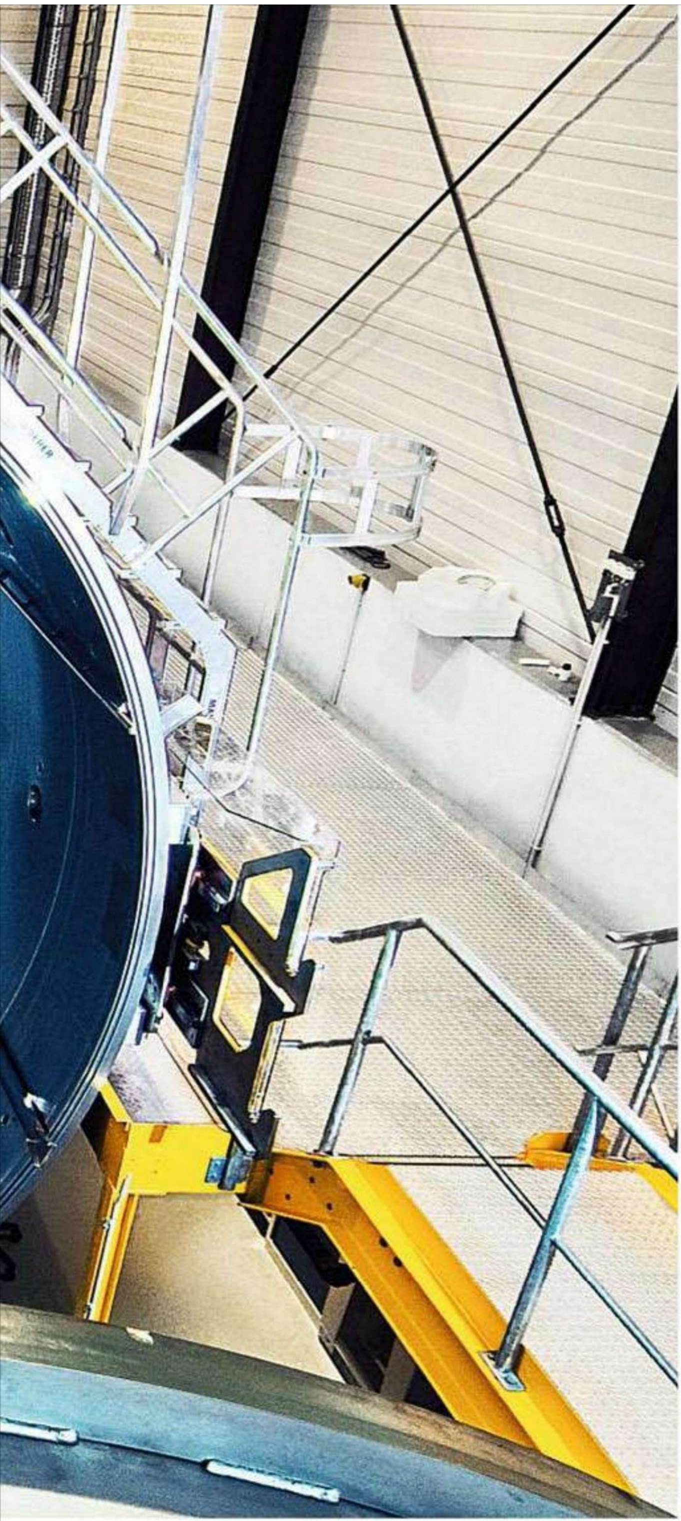
"There is no doubt that there will be a serogroup B meningococcal vaccine; once we have that, we can talk about eliminating meningitis. Also, there is a lot of promise in the malaria vaccine being developed by GlaxoSmithKline. I'm going to predict, however, that we will not have an HIV vaccine within ten years."

Margaret McGlynn
CEO, International Aids Vaccine Initiative (IAVI)

"We will likely see a universal flu vaccine within ten years; one that's effective against all strains of seasonal influenza and would not have to be produced anew each year, as it is today. Also, given recent breakthroughs in HIV research, we will probably have HIV vaccine candidates in advanced stages of clinical development within the decade."

Marie-Paule Kieny
Director, WHO Initiative for Vaccine Research

"In order for a new vaccine to become available during the next decade, it should already be in the discovery process. My personal shortlist includes a malaria vaccine which protects more than 60 per cent of children against severe disease, a vaccine against addiction, a vaccine made in plants and a vaccine administered by aerosol."



Terra firma's space chamber

Need to test rocket thrust in suitably spacey conditions? Propel yourself toward Germany…

The German Aerospace Centre, or Deutsches Zentrum für Luft- und Raumfahrt (DLR), is experiencing deep space. At the heart of the complex in Göttingen, central Germany, is a €4 million (£3.3 million), 236m^3 vacuum chamber in which scientists can research electric spacecraft-propulsion technologies without having to lift off.

A spacecraft's ion engines generate thrust by accelerating beams of positively charged particles at high speed using an electric field. But ion-beam technology isn't perfect and can interfere with and damage spacecraft parts, putting sensitive equipment such as solar panels out of action. So DLR researchers are developing engines that can minimise this kind of damage, as well as looking at materials that might be less likely to fail. "Our instruments are very sensitive," says Andreas Neumann, chamber manager at DLR. "So the challenge is to isolate the chamber from outside vibrations."

Inside the five-metre-wide, 12-metre-deep tube, researchers have enough room to fit entire sections of satellites alongside their engines. Once the chamber is sealed by its 4.5-tonne lid, the gas pressure inside it is lowered by a helium-based cryogenic pump, creating the vacuum. Running liquid helium through the walls brings the temperature down to -268°C; the walls are kept cold to ensure no ion exhausts will reflect back into the chamber – at these temperatures, gas particles will freeze as they hit the walls. It's the closest you can get to deep-space conditions on Earth. **Jeremy Kingsley** *dlr.de*

Andreas Neumann (*left*) and André Holz view an electric-propulsion system inside the vacuum chamber

Jean Stéphenne
CEO, GlaxoSmithKline Vaccines

"No health intervention is as powerful and cost-effective as vaccination, yet its potential remains untapped. Research points to a new generation of vaccines to protect against malaria, control chronic infections, and fight cancer – by harnessing our immune systems to recognise and attack tumours. The next chapter in the vaccines story is a promising one."

Andrew McMichael
Honorary director, MRC Human Immunology Unit

"I would like to say that we will invent an Aids vaccine in the next ten years but taking it through the necessary testing, manufacturing and licensing will take a further five to ten years. There is promise that a better TB vaccine will be in a more advanced position. A flu vaccine that could counter a new pandemic is also a realistic possibility."

Adrian Hill
Director, Jenner Institute for Vaccines, Oxford University

"The most exciting vaccine will be against Alzheimer's – the market for that is enormous. There's a 20 to 30 per cent chance it will get licensed in ten years. There will probably also be an anti-nicotine vaccine within ten years. And at the conceptual stage are vaccines that people can take in middle age, to prevent, rather than cure, specific cancers."

Peter Johnson
Chief clinician, Cancer Research UK

"We now know how to release the power of the immune system to recognise cancers much better than before, so we will see more vaccines that get the body's immune system to target abnormalities in a patient's cancer. The vaccines with most work behind them at the moment are against bowel and prostate cancer, and potentially lung cancer." MV

Want to work at Google?

Oxbridge can no longer claim to ask the most left-field interview questions

It's famously tough getting through the Google interview process. But now we can reveal just how strenuous are the mental acrobatics demanded from prospective employees. Job-seekers can expect to face open-ended riddles, seemingly impossible mathematical challenges and mind-boggling estimation puzzles. William Poundstone, who deconstructed The Wolseley's menu for us (04.10), has collected examples in his latest book, *Are You Smart Enough to Work at Google?* (Little, Brown). Here are 21 of the most brutal – and if you want to know the solutions, see *wired.co.uk/googanswers*. **MV**

CAN YOU SWIM FASTER THROUGH WATER OR SYRUP?

YOU WORK IN A 100-STOREY BUILDING AND ARE GIVEN TWO IDENTICAL EGGS. YOU HAVE TO DETERMINE THE HIGHEST FLOOR FROM WHICH AN EGG CAN BE DROPPED WITHOUT BREAKING. YOU ARE ALLOWED TO BREAK BOTH EGGS IN THE PROCESS. HOW MANY DROPS WOULD IT TAKE TO DO IT?

DESIGN AN EVACUATION PLAN FOR SAN FRANCISCO

USE A PROGRAMMING LANGUAGE TO DESCRIBE A CHICKEN

THERE'S A LATENCY PROBLEM IN SOUTH AFRICA. DIAGNOSE IT

YOU HAVE *N* COMPANIES AND WANT TO MERGE THEM INTO ONE BIG COMPANY. HOW MANY DIFFERENT WAYS ARE THERE TO DO IT?

YOU ARE SITTING IN A CAR WITH A HELIUM BALLOON TIED TO THE FLOOR. ALL OF THE WINDOWS AND BOOT ARE CLOSED. WHEN YOU STEP ON THE GAS PEDAL, WHAT WILL HAPPEN TO THE BALLOON? DOES IT MOVE FORWARDS, BACKWARDS OR STAY PUT?

HOW DO YOU FIND THE CLOSEST PAIR OF STARS IN THE SKY?

YOU WANT TO MAKE SURE THAT BOB HAS YOUR PHONE NUMBER. YOU CAN'T ASK HIM DIRECTLY. INSTEAD YOU HAVE TO WRITE A MESSAGE TO HIM ON A CARD AND HAND IT TO EVE, WHO WILL ACT AS A GO-BETWEEN. EVE WILL GIVE THE CARD TO BOB AND HE WILL HAND HIS MESSAGE TO EVE, WHO WILL HAND IT TO YOU. YOU DON'T WANT EVE TO LEARN YOUR PHONE NUMBER. WHAT DO YOU ASK BOB?

YOU ARE SHRUNK TO THE HEIGHT OF A 2P COIN AND THROWN INTO A BLENDER. YOUR MASS IS REDUCED SO THAT YOUR DENSITY IS THE SAME AS USUAL. THE BLADES START MOVING IN 60 SECONDS. WHAT DO YOU DO?

IF YOU HAD A STACK OF PENNIES AS TALL AS THE EMPIRE STATE BUILDING, COULD YOU FIT THEM ALL IN ONE ROOM?

IT IS DIFFICULT TO REMEMBER WHAT YOU READ, ESPECIALLY AFTER MANY YEARS. HOW WOULD YOU ADDRESS THIS?

ADD ANY STANDARD ARITHMETIC SIGNS TO THIS EQUATION TO MAKE IT TRUE:

3 1 3 6 = 8

YOU HAVE A CHOICE OF TWO WAGERS: ONE, YOU'RE GIVEN A BASKETBALL AND HAVE ONE CHANCE TO SINK IT FOR £1,000. TWO, YOU HAVE TO MAKE TWO OUT OF THREE SHOTS, FOR THE SAME £1,000. WHICH DO YOU PREFER?

USING ONLY A FOUR-MINUTE HOURGLASS AND A SEVEN-MINUTE ONE, MEASURE EXACTLY NINE MINUTES

YOU'VE GOT AN ANALOGUE WATCH WITH A SECOND HAND. HOW MANY TIMES A DAY DO ALL THREE HANDS OVERLAP?

HOW MUCH WOULD YOU CHARGE TO WASH ALL THE WINDOWS IN SEATTLE?

HOW MUCH TOILET PAPER WOULD IT TAKE TO COVER THE ENTIRE STATE?

WHAT IS THE MOST BEAUTIFUL EQUATION YOU HAVE EVER SEEN?

A MAN PUSHED HIS CAR TO A HOTEL AND LOST HIS FORTUNE. WHAT HAPPENED?

IMAGINE A COUNTRY WHERE ALL THE PARENTS WANT TO HAVE A BOY. EVERY FAMILY KEEPS HAVING CHILDREN UNTIL THEY HAVE A BOY. THEN THEY STOP. WHAT IS THE PROPORTION OF BOYS TO GIRLS IN THIS COUNTRY?

ILLUSTRATION: DENIS CARRIER

THE IG NOBEL'S FINEST

The *Annals of Improbable Research* highlights unlikely scientific papers – research that makes readers "laugh and then think". The very best get an Ig Nobel prize. Here are the journal's editor Marc Abrahams's all-time favourites.
Jeremy Kingsley ***improbable.com***

Transportational Planning Prize 2010
A Japanese team won an Ig Nobel for research suggesting slime mould could determine optimal routes between the stations on railway networks.

Safety Engineering Prize 1998
Troy Hurtubise from Ontario developed a suit of armour capable of withstanding a grizzly-bear attack. Hurtubise tested his exoskeleton on bears in Canada.

Linguistics Prize 2007
Juan Manuel Toro at the University of Barcelona demonstrated that rats can't tell the difference between Japanese spoken backwards and Dutch backwards.

Peace Prize 2007
The Wright Laboratory, an official US Air Force lab in Ohio, worked on a "gay bomb". The chemical weapon would have made enemy soldiers irresistible to one another.

Physics Prize 2000
Andre Geim of the University of Manchester won the Ig for physics for experiments using magnets to levitate frogs. Still, he bounced back to win a real Nobel in 2010.

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Crowdsourced mnemonics

Ed Cooke taught memory skills to Joshua Foer – now he wants to teach you to speak foreign languages

Ed Cooke likes to memorise things – a pack of cards in 45 seconds; a 1,000-digit number in an hour. He has even served as memory coach to Joshua Foer, who wrote the 2011 non-fiction bestseller *Moonwalking with Einstein: The Art and Science of Remembering Everything*. Now he's using his skills to help the rest of us learn foreign languages. His startup, Memrise, uses cognitive science and crowdsourced mnemonics to teach vocabulary in about 100 languages, from Catalan to Haitian Creole. Anyone can upload a word list and users can suggest new mnemonics – called "mems". "A mem is anything that enchants learning," says Cooke, 30, who splits his time between London and Boston. "Whenever you learn something, you always connect it with something you know. Mems help you make that connection."

The site, which he soft-launched in the summer of 2010 with Princeton neuroscientist Greg Detre, now has about 50,000 users, with 500 joining every day. It's being backed with $1 million (£600,000) by Matt Mullenweg of Automattic, Kenneth Lerer from the Huffington Post and Nabeel Hyatt, who founded Conduit Labs. Cooke says that some content may eventually go premium, but in the meantime he is harnessing user data to fine-tune Memrise's functionality.

"I'm amazed how subtle and complex memory is, and how beautifully it can be interfered with," he says. "We want learning to be less effort and more fun." **DB** *memrise.com*

Name: ED COOKE
Occupation: CEO, MEMRISE
Location: LONDON
Need to know: HE'S HARNESSING THE POWER OF MNEMONICS TO MAKE LANGUAGE LEARNING EASIER

PHOTOGRAPHY: ALEX LAKE

NATURE, AS SHOT BY CITIZEN SCIENTISTS

"The high-speed camera is the new microscope but it's just for the rich," says David Lentink, 36, an assistant professor of mechanical engineering at Stanford University. "So we began lending this incredibly expensive camera to ordinary people."

Lentink (then assistant professor of experimental zoology at Wageningen University) and his team had a pot of money from winning an academic prize. The university matched the amount, enabling Lentink to spend €200,000 (£170,000) on 30 Casio EX-F1 HD video cameras – capable of shooting up to 1,200 frames per second – and one €140,000 Phantom camera (7,500fps in HD). The equipment was for Flight Artists, a programme to capture natural flight that is open to anyone who wants to participate.

The aim is to expand Lentink's previous study of bird and insect biomechanics that had led him, with his aerospace-engineering background, to develop the free-flight ornithopter, the DelFly, and the morphing-wing micro-aerial vehicle, RoboSwift. The result is over 1,400 films so far, shot by over 400 members of the public, documenting everything from the behavioural acrobatics of fruit flies to the baffling sight of geese flying upside down. "Initially, I was hoping for one good movie from each participant after a day's training and two days with the camera. But we got many, many more."

The team is currently uploading selected films to a dedicated YouTube channel, all of which are available free to use for non-commercial research and as teaching tools. "We benefit from having so many people shooting for us – everyone had different ideas of what would be interesting, so we were bound to find cool things. If we'd just lent these cameras to a scientist it would have been amazingly boring." And is there anything left on his wish-list? "I want a high-speed movie of mating swifts: two seconds mid-air and it's over. It's incredible." **Duncan Baizley** *flightartists.com; youtube.com/vliegwinnaars*

Below: a dove filmed by Willem Hoebink and Xander van der Sar

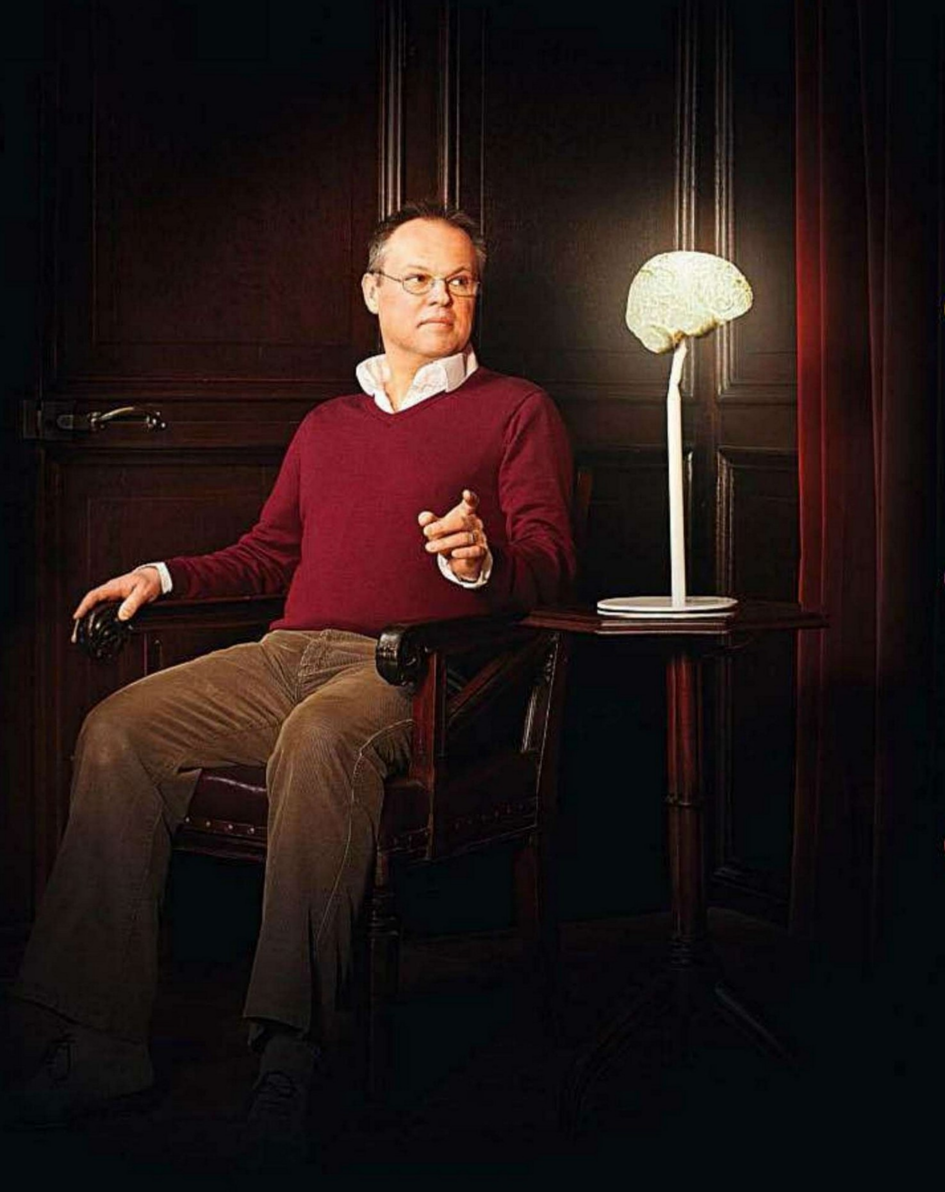
Neuroscience's illuminator

Gero Miesenböck is revealing our brains' inner workings by shining a light on flies

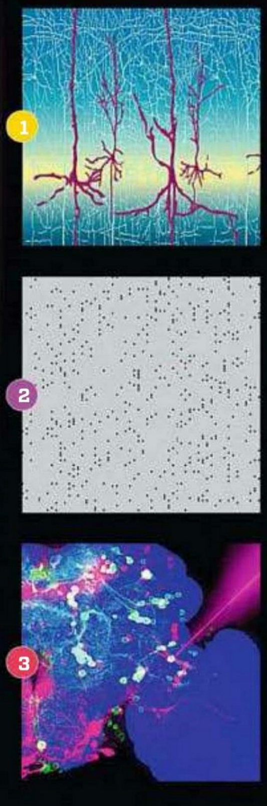
Do fruit flies feel guilty? Gero Miesenböck, professor of physiology at Oxford University, is exploring possible answers by literally shining light on the subject. Miesenböck, 46, is a pioneer of the science of optogenetics. Proposed by Francis Crick in 1999, and first demonstrated in the lab three years later by Miesenböck, optogenetics involves genetically modifying neurons in living creatures so they become light-sensitive, and then controlling them by switching a light on and off. "Neuroscience has been able to observe the brain in great detail but was less able to tinker with the thing," he says. "Now we have a chance to play with the symbols in the brain and see what they do, like a code breaker."

Miesenböck assigns light-sensitive characteristics to groups of cells in fruit flies' brains. He then switches a light on when they venture near a certain smell. Those that avoid that smell later are dissected to see which cells were sensitive to light. The result has been the discovery of a 12-neuron system that manages the flies' self-critical feelings, he says – "the superego, if you like". Now we just need a way to make wasps feel bad about picnics. **David Baker**

Name: GERO MIESENBÖCK
Occupation: OPTOGENETICIST
Location: OXFORD
Need to know: HE IS USING LIGHT TO REVEAL THE ROLE OF NEURONS



WHAT HE SEES INSIDE THE BRAIN



1. Light-sensitive neurons are activated by a flash of light
2. Simulation of nerve cells firing – each dot is a cell
3. Close-up of a "light-addressable" fruit-fly brain

PHOTOGRAPHY: JAY BROOKS

emirates.com/uk

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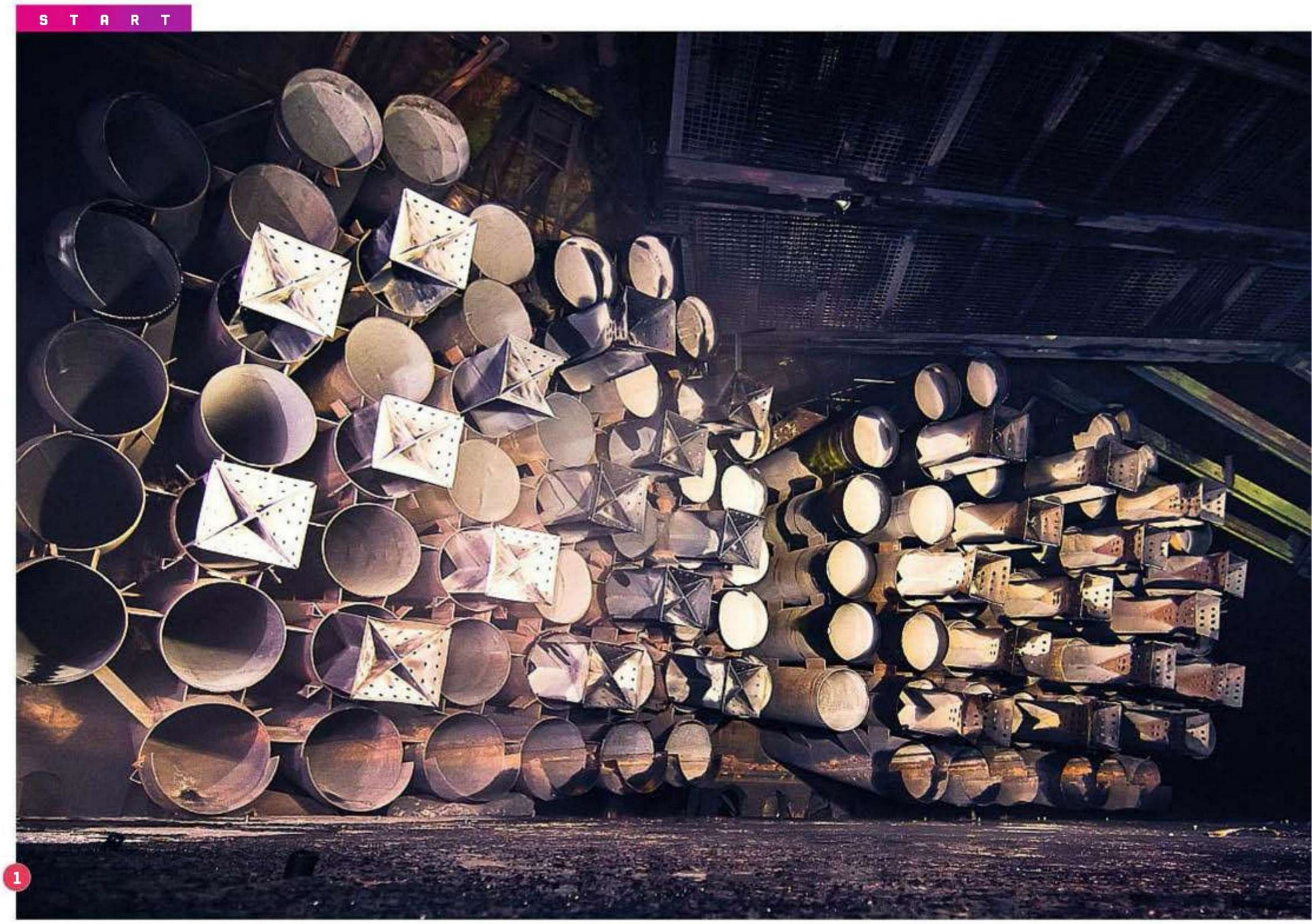


Sneak inside a rocket factory

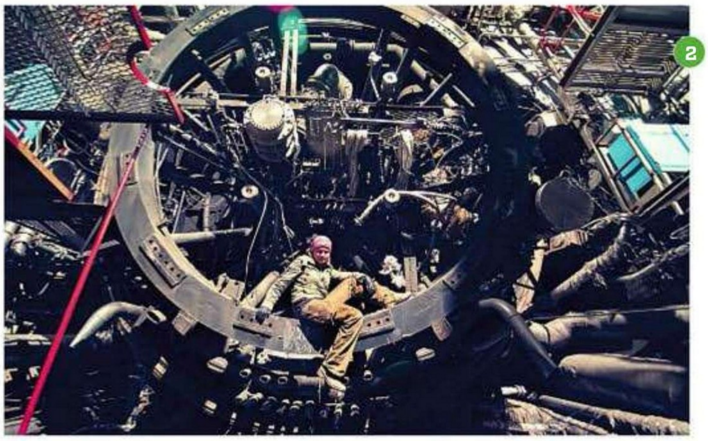
Lana Sator's urbex photo expeditions have earned the Russian authorities' ire

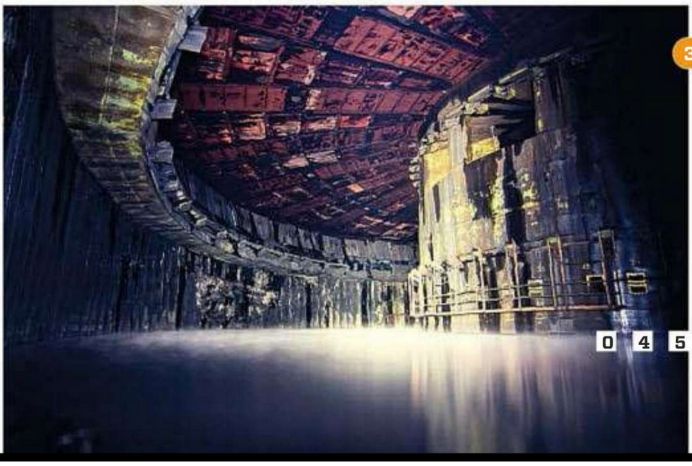
This military-rocket factory in Khimki, just outside Moscow, is off-limits to photographers. In December 2011, blogger Lana Sator (*right*), 23, and her friends snuck unchallenged into the active plant owned by NPO Energomash, one of Russia's oldest rocket-engine makers, through a hole in the fence, a camera in her hand.

Sator's activity is known as "urbex" – the exploration of abandoned structures such as mental asylums, underground factories and hospitals. "We also try to find and infiltrate into active places, such as industrial plants, refugee centres and bomb shelters at ⟶

1. Exhaust pipes which will eventually be fitted on to two space rockets
2. Lana Sator perching on a piece of machinery at the NPO Energomash plant
3. Inside the plant. Although it appears to be deserted, it is still operational

PHOTOGRAPHY: LANA SATOR/CATERS NEWS

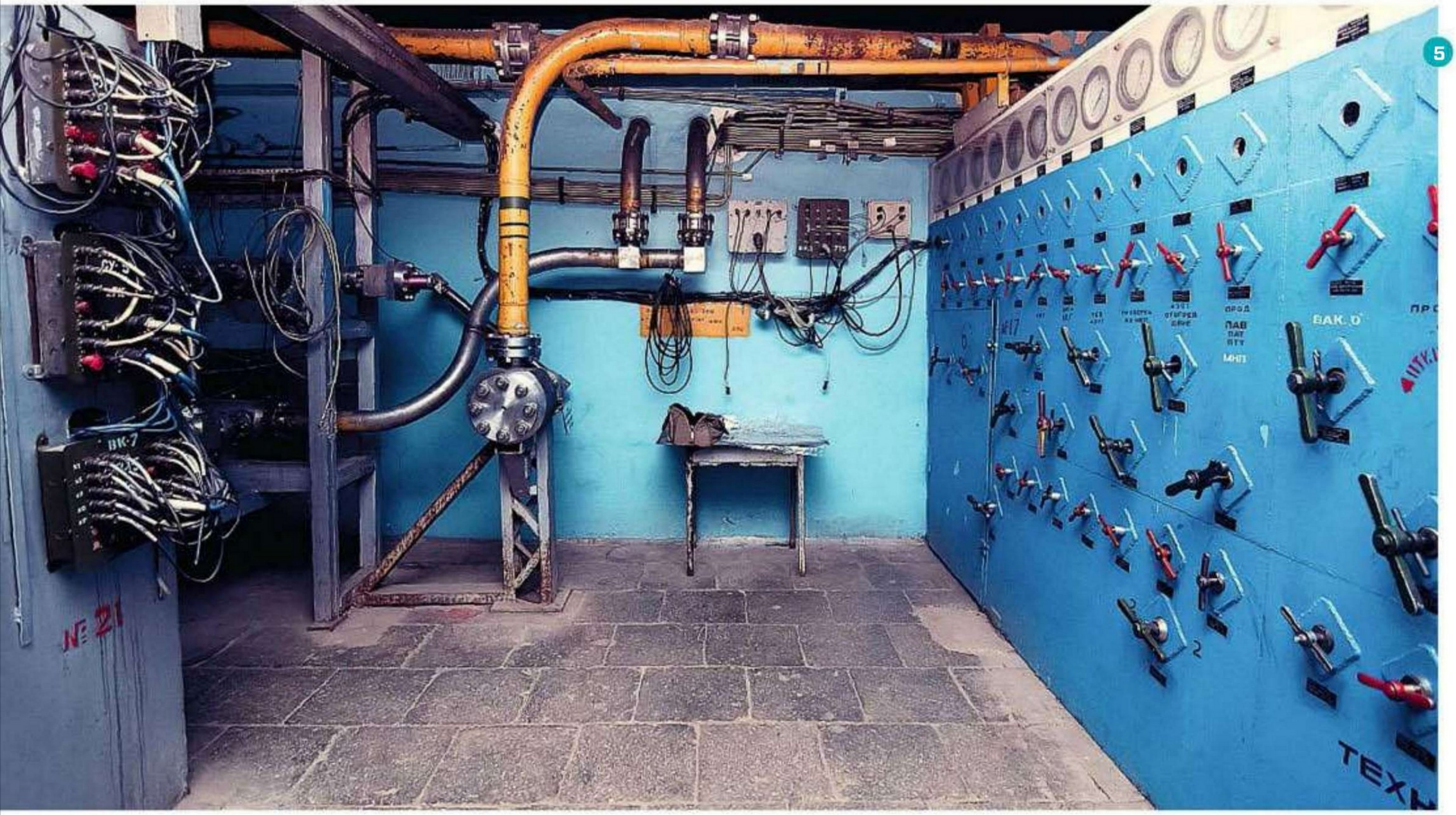




night," says Sator. The NPO Energomash plant develops space-shuttle boosters and missile engines for the military. Sator found it completely unguarded. "For five evenings in a row, we walked around the grounds, looking for open doors," she tells WIRED. "Military plants and bases [in Russia] are too easy for infiltration."

Soon after publishing her photos online, the Russian military police arrested Sator. "I spent my New Year's weekend in Ukraine, and when I came back they met me at the airport," she says. Despite official warnings, Sator says she will not stop exploring and photographing. Beats your typical holiday snaps. **Jake Hanrahan**
lana-sator.livejournal.com

4. Outside the rocket plant – Sator claims she encountered no security measures during her secret visit
5. A panel full of gauges in a control room inside the plant



WIRED	TIRED	EXPIRED
Slacklining	Wall trampolining	Parkour
Amasia	Asia	America
Choe	TOX	Banksy
Screenwise	Nielsen	Democracy
Graphene Gulch	Silicon Heath	Silicon Roundabout

PHOTOGRAPHY: LANA SATOR/CATERS NEWS

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SEE NEXT PAGE.
ENVIOUS GLANCES COME AS STANDARD.

CITROËN

Official Government Fuel Consumption Figures (litres per 100km/mpg) and CO_2 Emissions (g/km). Highest: DS3 Ultra Prestige THP 155 6-speed manual: Urban 8.2/34.4, Extra Urban 4.7/60.1, Combined 6.0/47.1 and 139 CO_2. Lowest: DS3 Ultra Prestige e-HDi 110 Airdream 6-speed manual: Urban 4.6/61.4, Extra Urban 3.4/83.1, Combined 3.8/74.4 and 99 CO_2.

WHAT'S INSIDE:
FISHERMAN'S FRIEND (BLACKCURRANT)

Countdown to clear sinuses

Unblock your nose with a mix of firework fuel and basketry dye

Each month WIRED's chemist Dr John Emsley deconstructs an everyday product. He is the author of 110 research papers and ten books, including his most recent: *Nature's Building Blocks, 2nd edition* (OUP)

INGREDIENTS

Sorbitol
Menthol
Acesulfame K
Wild elderberry
Blackcurrant flavour
Magnesium stearate

SORBITOL
A natural sweetener found in apples, peaches and prunes, it is known to act as a laxative. Mixed with potassium nitrate, sorbitol can be used as a rocket fuel for homemade fireworks.

MENTHOL
The active ingredient in these lozenges, menthol has a cooling effect because it can trigger the cold-sensitive receptors when it contacts the skin, the nose or the throat.

ACESULFAME K
An artificial sweetener 200 times sweeter than sugar. When blended with other artificial sweeteners, it in turn reinforces their sweetness, so less is needed.

WILD ELDERBERRY
Used as a basketry dye, the fruit and stems give a black colour. Here, it makes the lozenges purple. Elderberries are also claimed to stimulate the immune system.

BLACKCURRANT FLAVOUR
Derived from myrtillin, a salt-like anthocyanin. The flavour's popularity in the UK may be due to the free blackcurrant cordial given to children during WWII.

MAGNESIUM STEARATE
This helps the tablet to disintegrate when it is moistened by saliva. Magnesium stearate also keeps the tablets from sticking to the machinery used in their manufacture.

PHOTOGRAPHY: SCOTT GRUMMETT

www.citroen.co.uk

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ENVIOUS GLANCES COME AS STANDARD.

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Official Government Fuel Consumption Figures (litres per 100km/mpg) and CO_2 Emissions (g/km). Highest: DS3 Ultra Prestige THP 155 6-speed manual: Urban 8.2/34.4, Extra Urban 4.7/60.1, Combined 6.0/47.1 and 139 CO_2. Lowest: DS3 Ultra Prestige e-HDi 110 Airdream 6-speed manual: Urban 4.6/61.4, Extra Urban 3.4/83.1, Combined 3.8/74.4 and 99 CO_2.

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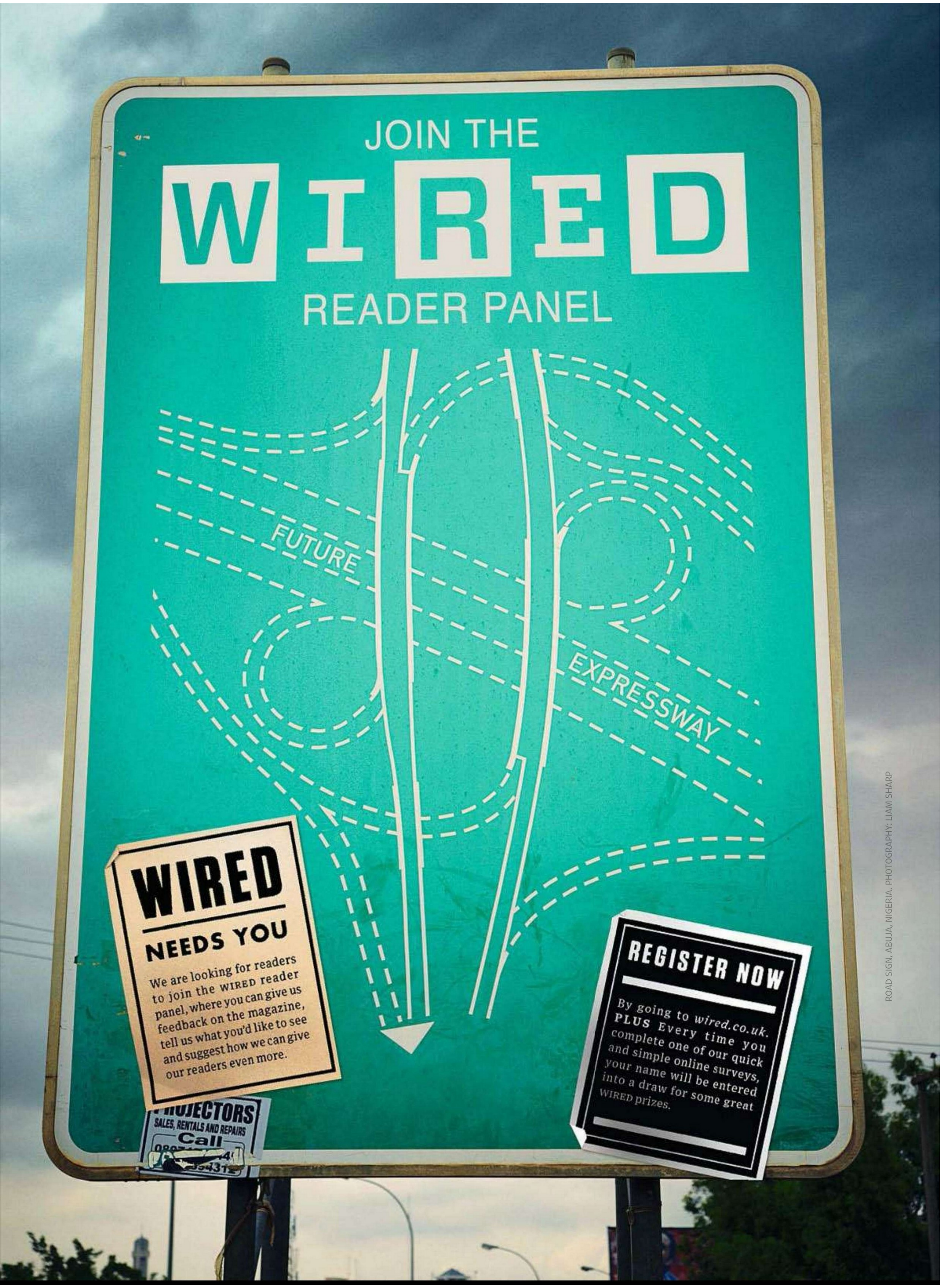

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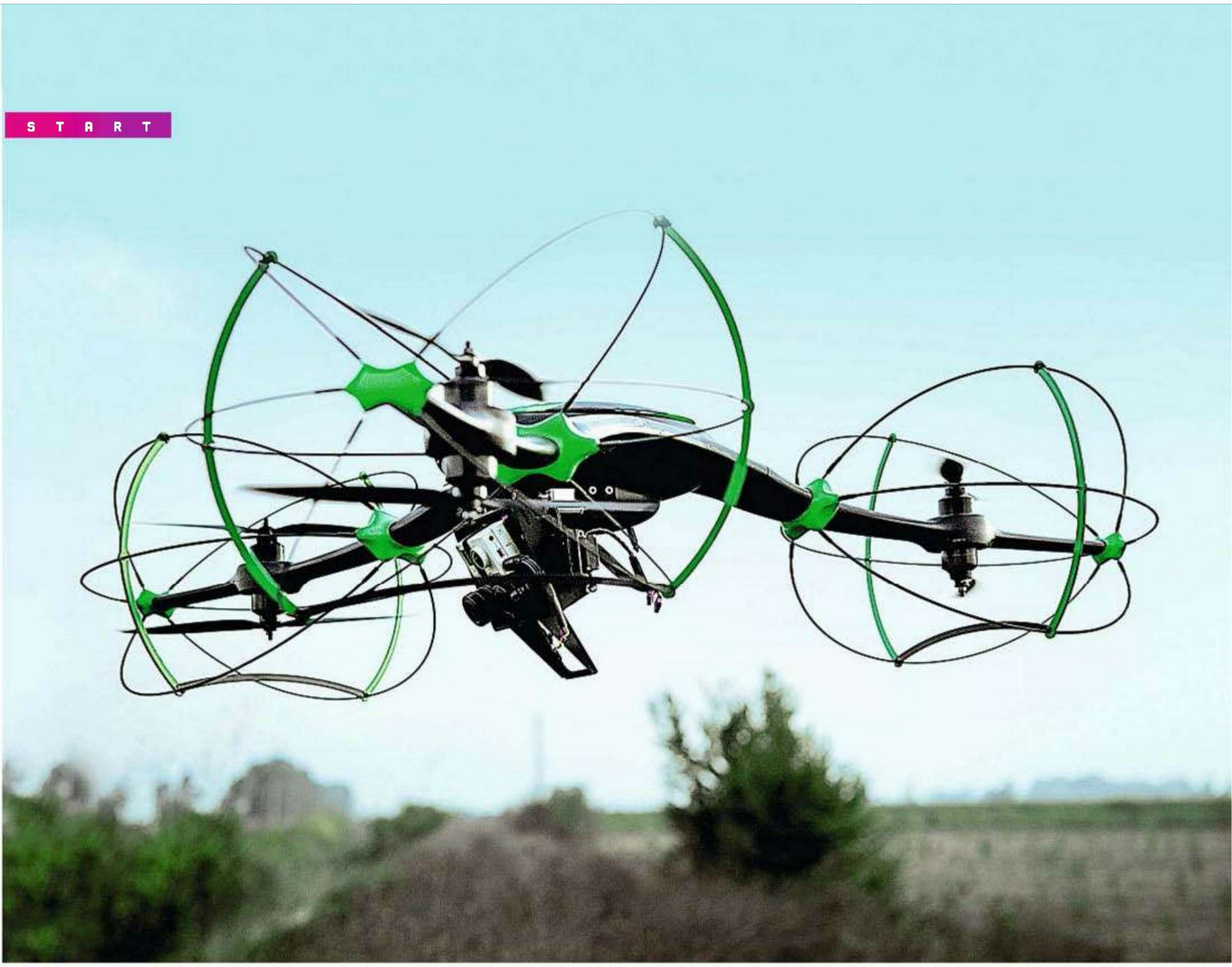
ROAD SIGN, ABUJA, NIGERIA. PHOTOGRAPHY: LIAM SHARP



StillFly's payload is sensors that collect data on pollutants and harmful hydrocarbons.

PHOTOGRAPHY: FRANCISCO PISTILLI. *NOVEMBER 2011

Eco crime's flying squad

Is it a bird? Is it a plane? No, it's StillFly – the newest weapon in the fight against illegal waste dumping

Buffeted by gusts of wind, we are flying high over Naples' business district, in the Campania region of Italy. We can see the whole area, even directly below us, through a pair of 3D video goggles.

The aircraft in which WIRED has just "flown" is the StillFly, a drone designed to beat eco criminals on their own turf. Massimiliano Lega, who devised and built it at the Parthenope University of Naples, says with undisguised pride: "We can get inside the pollution and map in 3D in real time. We analyse anomalous substances on water and trace their path back to the source, which is impossible with traditional methods. Only satellites have similar capabilities." Except satellites are 30,000km above the Earth, whereas the drones can slalom through urban canyons – and are thousands of times cheaper.

Drones have been used for military purposes as far back as the first world war, but are only now coming into their own. Lega has no doubts as to the potential extent of their use. At 40, after a stint at the University of California, Lega returned to Italy to dedicate himself to fighting environmental crime. The result of his research and development is the StillFly – designed and built in Italy.

The insect-like craft has a wingspan of a metre and looks like something from *Avatar*. It weighs only two kilograms thanks to its compact instruments, which include GPS sensors, an infrared camera, three accelerometers to keep it horizontal, a 3D vision system and a barometric altimeter. Yet this flying laboratory weighs less than a typical laptop.

THE WIRED INDEX

6h 59m

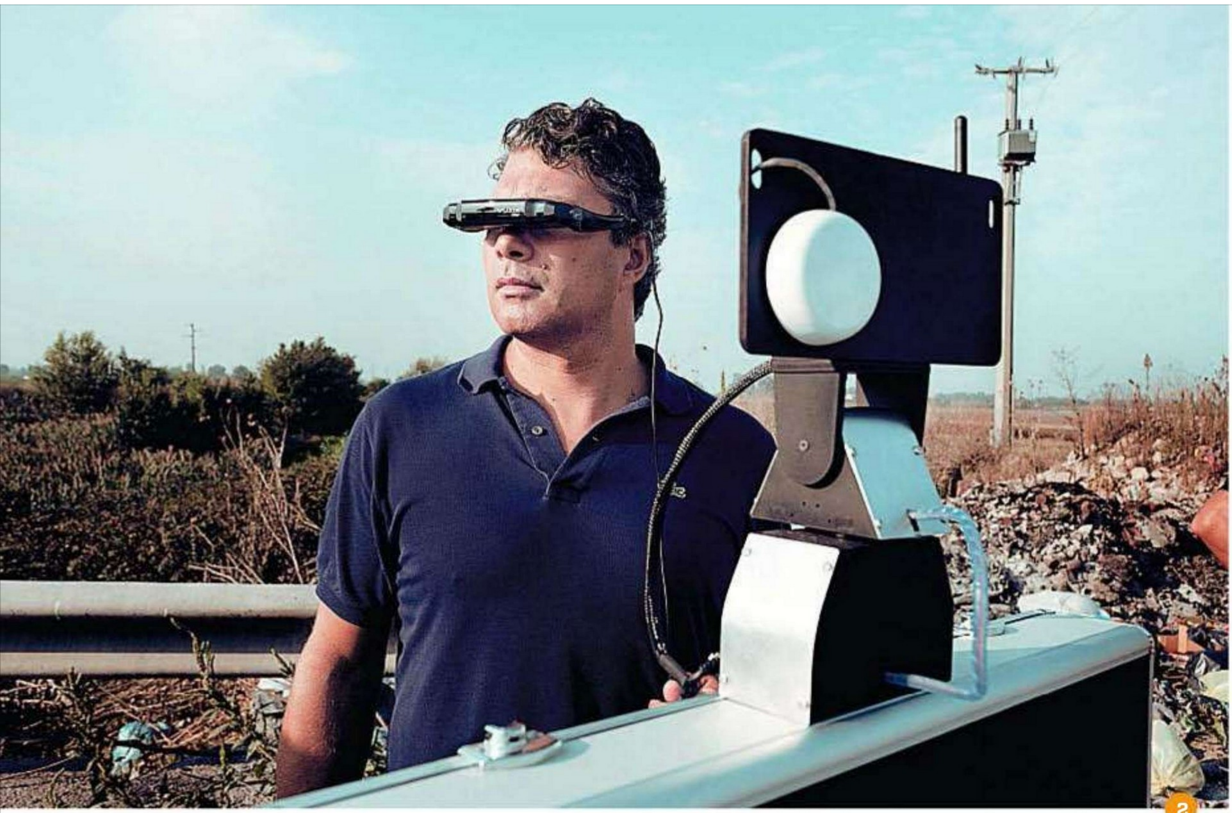
Time spent on Facebook per American, per month*

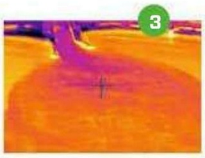
1h 44m

Time spent on Google per American, per month* *For sources, see Colophon (p154)*

While the pilot sees through the 3D video goggles, the investigators get a different view altogether. Lega shows us a monitor displaying a surreal-coloured landscape, generated by the drone's infrared sensors. "The yellow blob in the purple sea is sewage," he explains. "You can see its extent and even its origin. Now it's up to the coast guard to investigate and build a case." A few days earlier, Lega had spotted a tanker moored along the Neapolitan coast that was

→





1. The Italian Coast Guard is working with Lega's team to fight illegal waste dumping.
2. The pilot wears a 3D viewer to steer the craft and coordinate response teams.
3. The cameras use the infrared spectrum to detect subtle differences in heat.

washing out its oil tanks and pouring waste into the sea. The boat was anchored at the mouth of a river to disguise the illegal dumping in the plume of fresh water, but the StillFly's sensors had detected the unmistakable chemical signature of hydrocarbons. The tanker was immediately inspected by the coast guard and suffered two days' detention in port for releasing harmful substances into the sea.

Naples has developed a reputation for pollution and illegal dumping – much of it blamed on the mafia and unscrupulous businesses. Two of Europe's most polluted rivers – the Sarno and the Volturno – pass through the region. StillFly has succeeded here where more conventional policing has failed, spotting several cases of illegal dumping. In the coming months similar devices could be adopted by police units throughout Italy, and Nasa has recently announced an agreement with Lega's university to bring the technology to the US. Perhaps StillFly was an offer they couldn't refuse? **Jacopo Pasotti**

THE WIRED INDEX

ctrl + F

90% of internet users don't know Ctrl+F finds something on a page. *For sources, see Colophon (p154)*

START

A SCREENED: SOCIAL VOICE-MESSAGING

WIRED

Voxer
voxer.com
At first glance this app appears to turn your smartphone into a walkie-talkie. Voxer treats everything as a message so you have a record of all communications. You can listen to them again, faster if need be, and they can be emailed or posted on other social networking sites. *iOS, Android, Free*

Bubbly
bubblemotion.com
Bubbly lets you record a message or musing and then post it. Anyone following your voice logs will get an SMS to notify them of the posting. Unlike other voice-based social apps, Bubbly doesn't require a smartphone and will operate over most mobile phone networks. *Mobile network platform*

QWiPS
qwips.com
Tell the story behind a photo or video by annotating it with a QWiPS voice tag. The app lets you record up to 30 seconds of audio that you can share. QWiPS will let you tag SMS messages or add it to an email like a voice signature. Like other apps you can use the map function to search for nearby voice messages. *iOS*

Yiip
yiipapp.com
Combining nearly all these features, Yiip adds a push-to-talk messaging service. Chat in walk-talkie mode or browse recorded messages from within your social network or those publicly posted. It groups messages into categories, much like Twitter's hashtags, to make browsing easier. *iOS, Free*

WEIRD

HeyTell
heytell.com
Another push-to-talk walkie-talkie-like app, HeyTell will also let you change how your voice sounds as you hold a conversation with one or more people without being interrupted. Along with Facebook and Twitter integration HeyTell will let you add emoticons, geotag posts. *iOS, Android, Free*
Duncan Graham-Rowe

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COMPILED BY TILLY BULL

1 TOSHIBA PORTÉGÉ

Toshiba's latest, the Z830, is a lightweight dream machine at just 1.12kg and only 15.9mm thick. But don't be fooled by its size; this tough little laptop is equipped with a spill-resistant keyboard, magnesium alloy casing and even a cool fingerprint reader for that extra bit of security – so if you are prone to accidents, this might just be the perfect purchase. ***toshiba.co.uk***

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3 FASTHOSTS EMAIL

For communication on the go, it's critical to have an email platform that can synchronise seamlessly from the web to PC or iPad. Fasthosts Exchange 2010 offers a business class email with maximum security. Packages offer up to a 5GB mailbox, the latest Outlook 2010 software and the first two months free. Essential for connected businesses of any size. ***fasthosts.co.uk***

4 CERTINA DS MULTI-8

Swiss sports watch specialist Certina brings us the handsome DS Multi-8. Features include ETA eight-function analogue-digital movement, twin "time-swap" time zones, acoustic and vibro alarm options, and a sharp backlit display. This watch is a traveller's delight, and is available with either a smart leather strap or matching stainless-steel bracelet. *certina.com*

5 DOCKERS SHIRTS

It's no secret that the WIRED staff love their checked shirts – so we were pretty excited when this Dockers number turned up at the office. Made of unbelievably comfortable laundered poplin, it looks great tucked in for a day at work or worn loose and casual on the weekend. Available at the super-cool Boxpark popup mall in Shoreditch. ***gb.dockers.com***

PHOTOGRAPHY: SUN LEE

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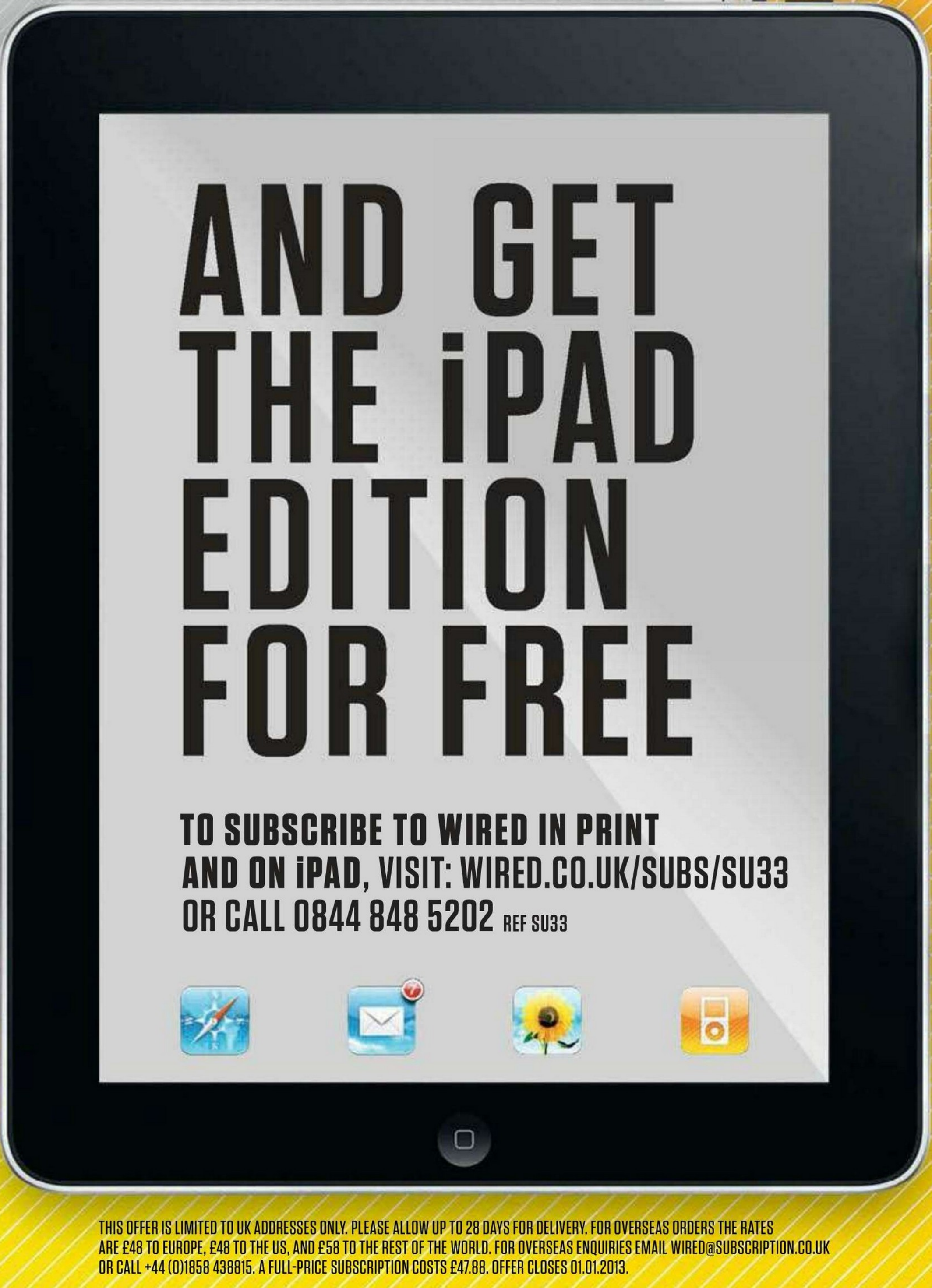

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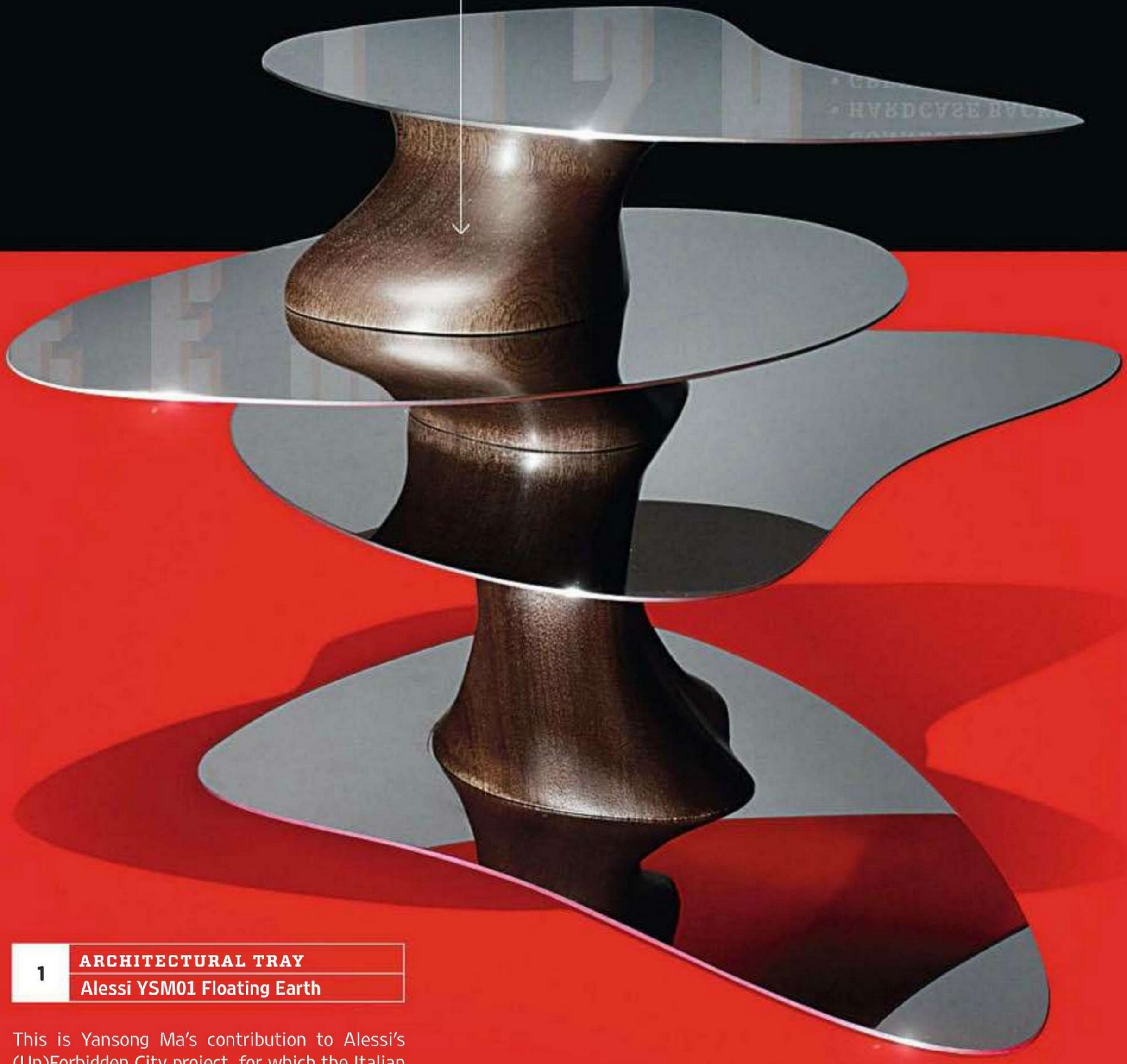
FETISH

OBJECTS OF DESIRE
THIS MONTH: 05.12

- THREE-TIERED TRAY
- CONNECTED CAR
- HARDCASE BACKPACK
- GREEN SPEED MACHINES
- MODERN MUSIC-MAKERS

EDITED BY JIM HILL



The Floating Earth's stem is made from mahogany

1 **ARCHITECTURAL TRAY**
Alessi YSM01 Floating Earth

This is Yansong Ma's contribution to Alessi's (Un)Forbidden City project, for which the Italian design factory asked eight Chinese architects to reinterpret the humble tray. The irregular structure of the stem provides more support for its stainless-steel surfaces than a symmetrical one. Too good for your TV dinner? *£349 alessi.com*

PHOTOGRAPHY: CHARLIE SURBEY. WORDS: JIM HILL

MINI Connected can put Facebook, Twitter and news on to your dash

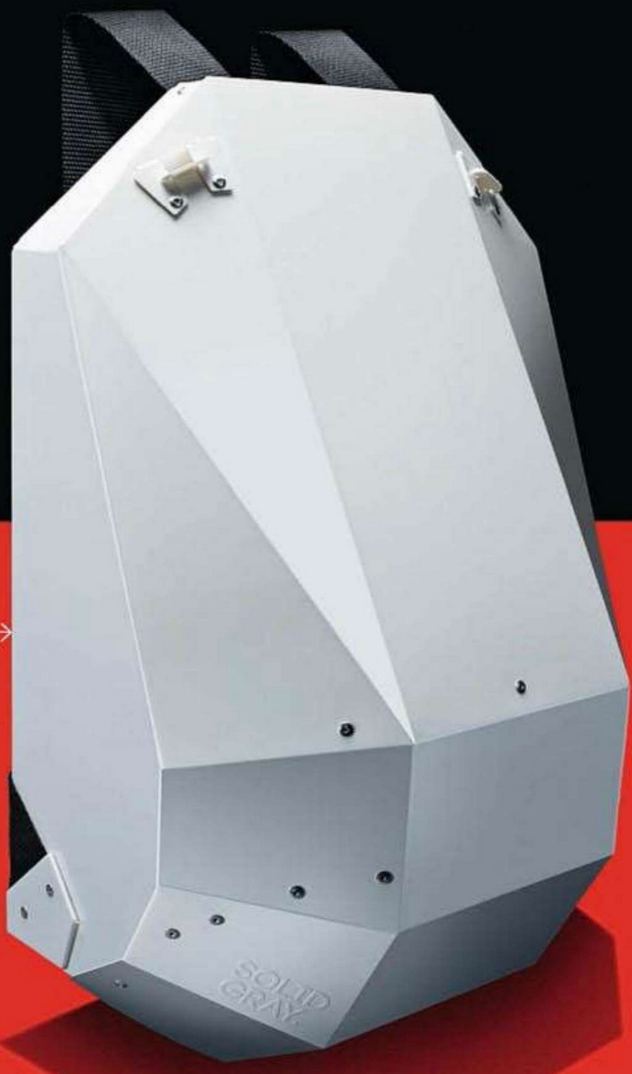
2

CONNECTED CAR

MINI John Cooper Works Roadster

This two-seater convertible has more boot space (240 litres) than the average roadster – there's even a compartment for stowing your skis. The Roadster can roar to 100kph in 6.5 seconds and comes with MINI Connected, a dash-mounted display into which you can plug your iPhone to run MINI's driver apps. *£24,850 mini.co.uk*

PHOTOGRAPHY: CHARLIE SURBEY.
WORDS: JIM HILL; SIMON MUNK



The Solid Gray's slightly curved back section flexes for a snug fit

3

HARDCASE BACKPACK

Solid Gray

The exterior of the Solid Gray backpack is inspired by an armadillo's carapace. It's formed from a sheet of polypropylene block copolymer, cut and folded to shape then secured with aluminium rivets. Inside, it is lined with EPDM foam and straps to hold your hardware, with a second pocket for smaller items. *€119 solid-gray.com*

The 9kWh powertrain is mounted on aircraft-grade aluminium

1 LONG-RANGE MOTORBIKE

Zero DS ZF9 electric motorcycle

This direct-drive, fully electric motorbike offers rapid acceleration off the line, and it doesn't let up until it reaches its 130kph limit. Improvements to power management and regenerative braking give the ZF9 a range of 180km (or 100km for motorway riding); traditional manufacturers will be taking a concerned look in their rear-view mirrors. *From £9,995 zeromotorcycles.com*

2

ELECTRIC POWERBOAT

Frauscher 650 Alassio

The 650 Alassio's Dutch-designed Mastervolt batteries are 70 per cent lighter than traditional lead cells and give the 6.5-metre-long boat an impressive 80-kilometre range. A streamlined hull helps the boat's 10kW motor cut economically and near-silently through water; the teak decking, however, is purely for style. *€48,120 frauscherboats.com*

3

PERFORMANCE MOTORING

Tesla Model S

The Tesla Model S is a stately four-door sedan, but because it uses the same electric powertrain as its Roadster cousin, it can accelerate to 96kph in just 5.6 seconds. Naturally, that requires a little more juice from the battery, which in this premium model is an 85kWh lithium-ion cell, giving a range of 500km and a top speed of more than 200kph. *$69,900 (US only) teslamotors.com*

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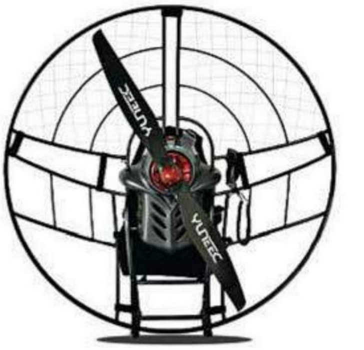
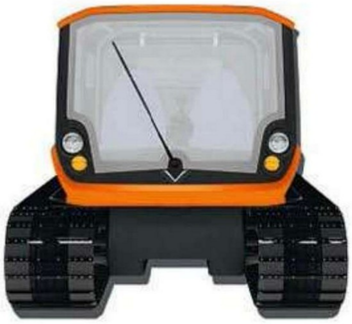




4

SILENT PARAMOTOR FLIGHT

Yuneec E-PAC

Attach a power kite to this lithium-battery-powered paramotor and it will launch you silently into the air. Yuneec's 3.8kg direct-drive brushless motor turns the two rotor blades with no vibration, noise or emissions. A joystick with integrated LCD panel makes it relatively simple to fly, and there's cruise control and a vibrating alert system on board, too. *£tbc yuneec.co.uk*

5

SUBZERO EXPLORATION

Venturi Antarctica

This tracked buggy was developed to meet the needs of scientists working in the Antarctic without polluting it. Two joysticks in the cabin control twin electric motors – left and right – that can operate at -50°C. Spreading its 1,200kg evenly to minimise pressure on the ground, the Antarctica can comfortably transport a tonne of kit over soft snow. *£tbc venturi.fr*

PHOTOGRAPHY: ANDREW JOHN SIMPSON; DAVE LIDWELL. WORDS: JIM HILL

1

TABLET TURNTABLES

Numark iDJ Live

iDJ Live works in conjunction with Algoriddim's Djay software to enable you to mix straight from your iPad, iPod Touch or iPhone. Crossfade, cut, stratch, EQ, loop and sync between digital tracks from your iTunes library. Familiar mixer functions are transferred to the device's plastic platters and dials for hands-on authenticity; musical taste, however, is not supplied. *£80 numark.com*

2

PRO-LEVEL PORTABLE MIC

Olympus LS-100

Integrated stereo mics make this ideal for capturing sound either in uncompressed 96kHz/24-bit linear pulse-code modulation (PCM) form, or just bootlegging gigs in 320kbps MP3. Dual XLR inputs, eight-track recording, an instrument tuner and a metronome also make it a handy tool for musicians, and an SD card slot lets you boost its 4GB memory to 64GB. *£399 olympus.co.uk*

MUSIC'S NEXT BIG THING

DO-IT-YOURSELF STUDIO TECH WITH A DIGITAL TWIST

3

PRO DJ CONTROLLER

Denon DN-MC6000

This pro-level, four-channel, eight-source mixer is ideal to use with DJ software such as Traktor. It's just as suitable for travelling DJs (it can be housed in a flight case) as it is rack-mounted into a booth. Two hardware platters can run up to four virtual decks simultaneously, and it's compatible with CDJs and vinyl turntables too. *£679 dm-pro.eu*

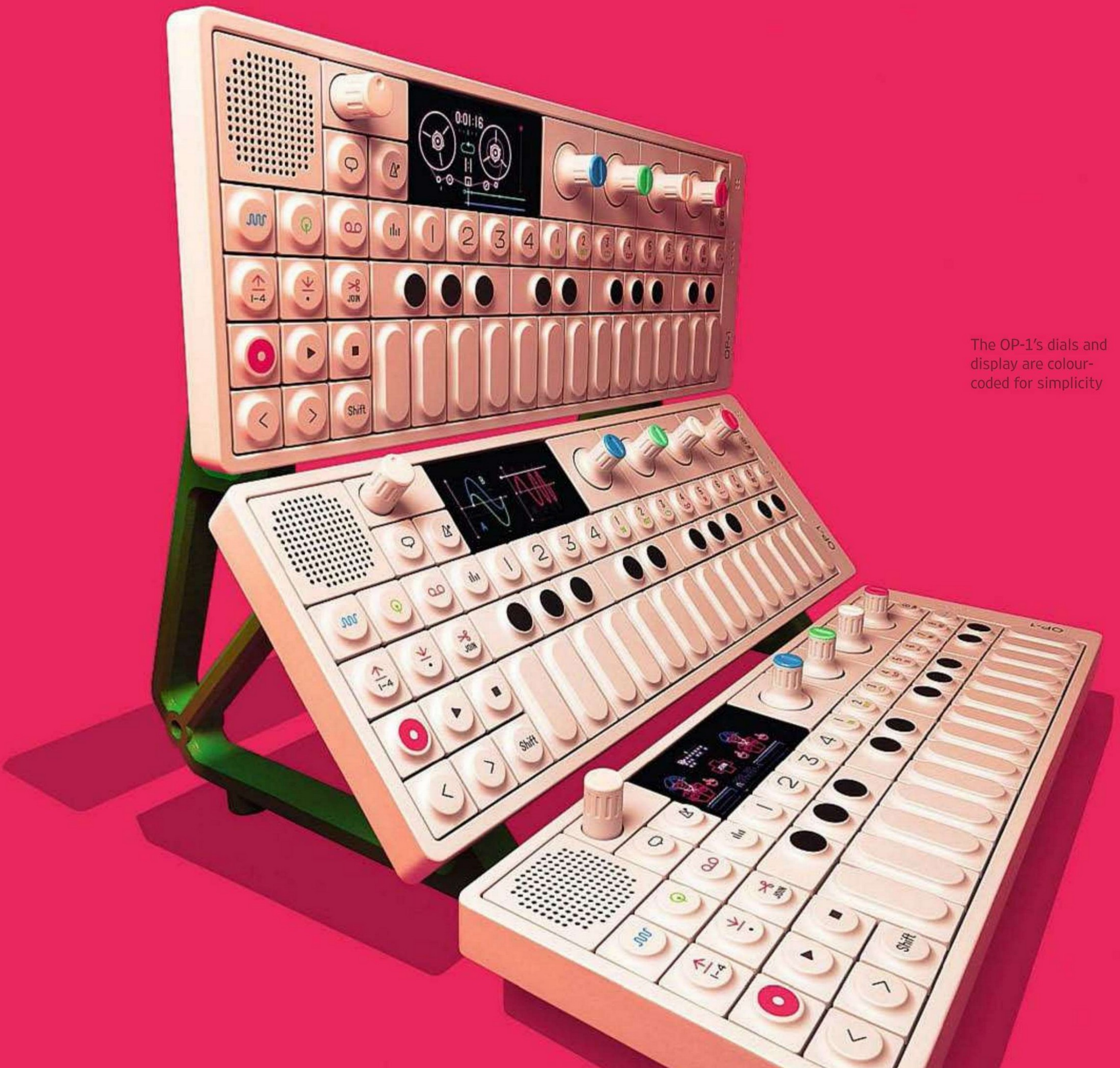
4

MINI MUSIC-MAKER

Native Instruments Maschine Mikro

The Maschine Mikro is a music production tool that lets you create rhythms and melodies on the fly. It's compatible with the *iMaschine* app, so you can also upload projects from your iOS device. The Mikro carries more than 6GB of samples, patterns and effects, but if that's not enough you can expand your machine with a series of plug-ins. *€349 native-instruments.com*

PHOTOGRAPHY: ANDREW JOHN SIMPSON; DAVE LIDWELL. WORDS: SIMON MUNK



The OP-1's dials and display are colour-coded for simplicity

5

ULTRA-PORTABLE STUDIO

Teenage Engineering OP-1

Three of these stylish synths take up less room than the average keyboard, and they're crammed with features. Each has a built-in four-track recorder with a variety of recording speeds; eight synth engines deliver effects and low-frequency oscillations. There's even an FM radio tuner included from which you can rip samples. *€799 teenageengineering.com*

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RUSSELL M DAVIES_PAUL J ZAK_JAMES BRIDLE_STEPHEN CAVE_ALEX BATEMAN_GREG WILLIAMS

RUSSELL M DAVIES_

History will remember Samuel Pepys's blog

Nine years ago – before YouTube, before Facebook, before Twitter, before it was easy – Phil Gyford started putting Samuel Pepys's diary online. More precisely, he put the entry for January 1, 1660, up on January 1, 2003, and he's been updating it ever since. Pepys wrote his last diary entry on May 31, 1669, so Phil will do the last update on May 31. And then have a party.

From the start it was clear that Pepysdiary.com meant something. Clay Shirky said in 2003, talking about the emergence of blogs: "The vertigo moment for me was when Phil Gyford launched the Pepys weblog... What that said to me was: Phil was asserting, and I now believe, that weblogs will be around for at least ten years, because that's how long Pepys kept a diary. And that was this moment of projecting into the future: this is now infrastructure we can take for granted."

In some worlds ten years isn't very long: it's not if you're digging an undersea tunnel or discovering a cure for disease. But in the busy, silly world of early 21st-century media, making a ten-year assertion was a big deal – something akin to the Clock of the Long Now.

Now, in the world of Twitter and *Instagram*, it looks even more quixotically patient and focused. And that's why the completion of Pepysdiary.com should be celebrated – it teaches us that the internet has power over other dimensions than the Social Graph and the Real-Time Web, that web success can be built with things other than venture cash, spammy PR and rapid scaling. Pepysdiary.com has a community because people found it, hung around and started contributing. And it isn't about making money – Phil does it for nothing, pouring in hours of work every week, out of love, dedication and, I suspect, a cussed determination to see something through. Crucially, it's not that modern web "for nothing", which means "no monetisation model now, but we'll build a billion users and work it out later". This is the non-commercial, hobbyist web that destroyed so many business models back then and which no one talks about any more.

But it's not like Phil is some sort of early 2000s Luddite, hanging on to an idea of a handmade web. He's not afraid to enhance things when appropriate technologies come along. It's become the definitive Pepys resource on the web, incorporating maps, annotations and community, everything linked in just the way the web does best. The Twitter account *@samuelpepys* has found the diaries a new audience – over 25,000 followers – and attracts frequent retweets from William Gibson, the ultimate demonstration of relevance and futurity.

I asked Shirky what he thinks about Pepysdiary.com in 2012. How does it feel now? "It feels like 2003, the year of Friendster, when everything social seemed new, but now seems as quaint as a sepia photograph. Most of all, it is obvious that Phil was right, and that his understanding of how important weblogs would become wasn't just spot on, but he also imagined, again ahead of us all, that there would come a day where that feeling of newness would *end*, that Samuel Pepys would tire of writing a diary the second time around too." Maybe that's the real lesson of Pepysdiary.com. We'll only really understand what we're doing when it stops feeling new, when we have a sense of history about what we're making.

Russell M Davies is a contributing editor at WIRED *and an occasional blogger at russelldavies.com*

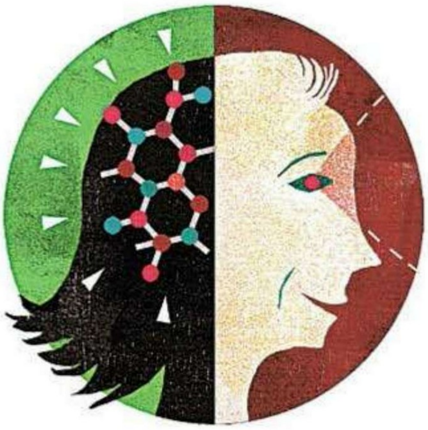


ILLUSTRATION: TOM JAY

PAUL J ZAK_

Corporate culture is key to personal fulfilment

A forceful takedown put me into a patch of cactus. It was a simulated engagement, but this felt real enough to me. I was on a night patrol with Reserve Officers' Training Corps cadets in the mountains of south California, and I had agreed to participate as an enemy combatant. I noticed the blood on my trousers only when I got in my car to leave.

Patrolling with the military is not something I typically do, but I've been trying to understand how organisations create culture. The US Army is an expert culture generator. After each contact between cadets and the "enemy", there was an immediate debrief identifying strengths and weakness of the interaction. The immediate feedback reinforces the idea there is an Army way to do things that every cadet needs to learn.

Culture is again a hot topic for businesses and society – but what exactly is culture? One take on culture is that it is a way for social creatures to transmit information to one another. Every organisation we inhabit creates its own culture, including one's family, workplace and gym. We absorb the culture to fit in and to follow what others do.

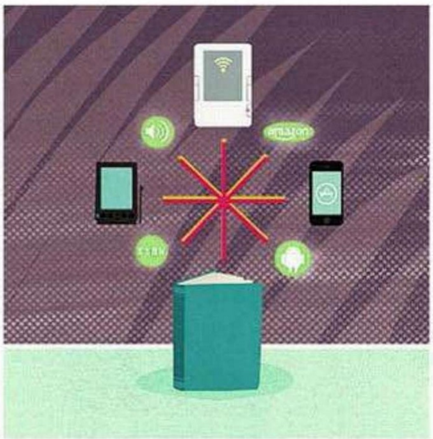
Cultures compete to be effective in helping their members reach goals through an evolutionary process of survival and reproduction. Cultures that produce results survive and flourish. Many organisations are defined by their cultures. A current favourite is zappos.com, an online clothing retailer with more than a billion dollars (£630 million) in annual revenue. I spent a couple of days with its CEO, Tony Hsieh, at the company's HQ in Las Vegas. It is culture crazy; it produces a "culture book" every year in which employees write uncensored blurbs about what happens at Zappos and how it feels. They give the book to anyone who wants it. Employees get feedback on how they're doing, and can talk to Hsieh any time they like.

Hsieh believes that Zappos' quirky and fun culture, focused on delighting customers with the highest levels of service, is the secret to its success. He's moving Zappos from the suburbs to downtown Las Vegas so that its culture of personal growth and having fun will infect the surrounding neighbourhood – and he wants North Vegas's artsy funkiness to infect the company's culture in return.

Hsieh believes he can sustain Zappos' growth by nurturing a sense of community among its employees so they'll be happy and productive. My neuroeconomics experiments show why individuals who release the most oxytocin after being trusted by a stranger are more satisfied with their lives. These "oxytocin adepts" excel at connecting with others, reporting better relationships with partners, family and friends. They also show fewer depressive symptoms and have greater resilience to adverse events.

Culture is bidirectional. It both affects who we are and is changed by who we become. Hsieh thinks he can scale his fun and happiness culture to other businesses and perhaps the world at large. The experiments I've run and the feeling I got visiting Zappos shows Hsieh just might be right.

Paul J Zak is the director at the Center for Neuroeconomics Studies, Claremont Graduate University, California. He is the author of The Moral Molecule *(Transworld)*



JAMES BRIDLE_

Literature needs much more than ebooks

Books produce a strong and highly emotional reaction in pretty much anyone forced to consider them. Despite the growth of ebooks, the comments one mostly hears are appeals to a book's physicality. Rarely are the arguments to do with literature itself, but this is because we find it so hard to parse what is important about the book.

Books are amenable to interaction analysis, yet those interactions are so complex, so embedded in our minds and in our culture, that it seems impossible to separate them from the thing itself. Books are encoded experiences, they are repositories of the experiences we have with them, and they are ultimately souvenirs of themselves. The publishing industry has long profited from this unique assemblage of product and meaning. As a result, it has been slow to respond, philosophically and organisationally, to the challenge of new media. Ebooks were initially dismissed, then grudgingly accommodated. Only with the growth of consumer demand and the ever-more-terrifying threat of the industry-eating Amazon has publishing attempted to innovate, supplying ebooks in at least a couple of formats, dipping a toe in the waters of interactive content.

But this innovation has been hampered by an entirely understandable misunderstanding of new technology and what it means for the book, as well as a historically misplaced idea of what constitutes "quality". The role of the editor – the filter, the gatekeeper – is not one of much value in a world which is as happy watching a cameraphone video as it is 3D IMAX. Books, and the publishing industry with them, have been radically decentred by technology. The most common metaphor employed by publishers trying to understand what is happening to them is the music industry, but this turns out to be an error. The radical ephemerality of the MP3 file suits music in the same way that it destabilises the book, which has always existed to provide the corresponding physical weight to literature's intellectual heft. Freeing the idea of the book from paper and hard covers thus entails reconceptualising what "the book" is – a weight that has proved hard for devices to take on.

Books are responsive, so we should take advantage of digital publishing and distribution to bring them to market faster and with greater relevance. Length and format are irrelevant in a non-physical world: poems and short stories become tradable commodities again. And values such as contextual editorship and typographical design, traduced for some time even in literary publishing, have the chance to find new and vibrant uses.

What we are coming to realise is that no one thing can pick up where the book left off; instead it is everything, all of our networks, our services, our devices, the internet plus everything else, which will carry literature forward. Literature is unique among art forms in that it is enacted entirely in the minds of author and reader; a psychic dance. Literature is everything, and thus everything must be employed in its support. And publishers, so long accustomed to doing a couple of things well, are adrift in a world that needs them to do everything – or GTFO.

James Bridle is a writer, publisher and artist based in London. booktwo.org

ILLUSTRATION: MARCUS BUTT; SKIP STERLING

STEPHEN CAVE_

One day, you'll live on in an avatar. Uh-oh...

If anything deserves to be called the Holy Grail of technology, then this is it: a system that, like the original Grail, would grant the power to bring back the dead. Let's call it avatar immortality. The idea is simple: the complete contents of your brain would be scanned regularly and archived. Then, should the worst happen – as it surely one day will – the scan would be used to provide the personality for a humanoid artificial intelligence, preferably in a suitably shapely body. The result of this mind uploading would be an avatar with your memories, beliefs, hopes and dreams – an avatar that thinks it is you.

And according to avatar immortality's advocates, it really would be you. They don't see it merely as a consolation that the avatar could continue your work, raise your children or engage in cheery banter with your friends: they see it as a way to beat death. So if You 1.0 gets hit by a bus, You 2.0 rolls out of the immortality factory and simply picks up where you left off.

A growing number of websites, institutes and research projects are already taking up the quest for this Grail. They have a long way to go: the technical challenges of scanning, storing and reactivating the required information are immense. But many futurists, from Gordon Bell, principal researcher at Microsoft Research, to Nick Bostrom, professor of philosophy at Oxford University, believe full-scale mind uploading is viable, desirable and coming your way before the century is out. They might be right; but they're wrong to think it a route to immortality. Even if your avatar could convince your mother it was you, it wouldn't be.

Imagine that the immortality factory is informed that you've been hit by a bus, and so You 2.0 rolls off the automated production line. But it's a mistake: You 1.0 is fine and has no idea your avatar has just been made. You only find out several days later when you wrestle with it for who gets to sleep with your spouse. This is known to philosophers as the duplication case.

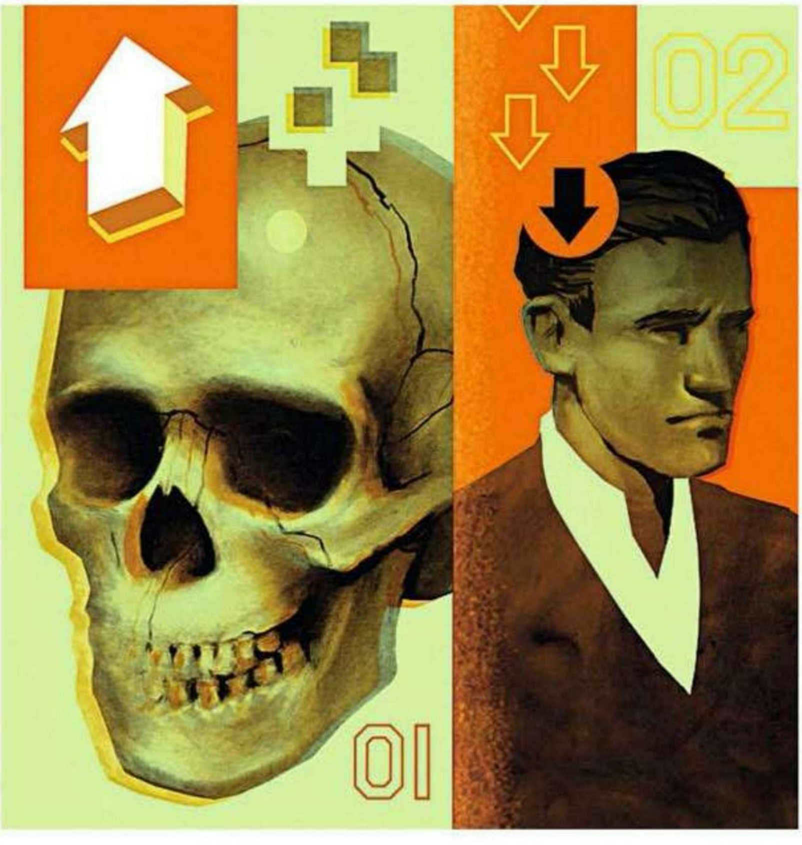
In this instance, you would never think you were the avatar – a physically separate being you might pass in the street. Yet the relationship between you and it – ie that it has exactly similar memories, beliefs etc to you — is just the same relationship that holds if the avatar is created after you die. It is a relationship, not of identity, but of similarity. You no more literally live on through your avatar than through your twin.

In the standard example, where you die and your avatar immediately blinks into life with all your psychological quirks, the continuity in the narrative creates the illusion of a continuity of self. But as soon as we tell the story a different way, such as your avatar being created before you die, this illusion of continuity is dispelled.

There is a fundamental reason that you can never live on as bits and bytes: it is that you are an animal, a unique exemplar of the species homo sapiens. Any animal comes to an end when its vital functions stop permanently. Building an avatar whose memories are based on yours would do as much to bring you back to life as would building a matchstick model of your pancreas.

As Woody Allen might have said: I don't want to live on in my avatar, I want to live on in my apartment.

Stephen Cave is a philosopher and the author of Immortality *(Biteback)*



ALEX BATEMAN_

Scientists should be publishing on Wikipedia

If someone had told me ten years ago that there would be a single website that the public would visit for information about science and technology, I would have laughed at them. The very notion seems the antithesis of the anarchic disorganised web. If they had then told me that I, and anyone with an internet connection, would be able to edit that website, I would have thought they had seriously lost the plot. But ten years after the birth of Wikipedia, this is exactly what we have.

If you want to know what a zedonk looks like, the chances are your search engine will point you first to Wikipedia. What most scientists have yet to realise is that Wikipedia offers a huge opportunity for engaging with the public and explaining their science.

As a scientist, I want the public to understand my research and why it is important. After all, it's usually their taxes paying for it. This public engagement traditionally involves giving a lecture at a science festival or talking to classes of children. I think that this is preaching to the converted. At best I might lecture to 100 people at a time. However, if I write or edit a Wikipedia article, my potential audience is some of Wikipedia's 365 million readers worldwide. Even if only a small fraction of these are interested in knowing what a genome is, it's still a pretty large number of people. The genome article in Wikipedia was viewed over half a million times last year.

The biggest surprise for me was that Wikipedia can provide completely new ways for scientists and the public at large to work together. My research group produces a database called Rfam about families of related RNA molecules. We use Wikipedia articles to describe each of the RNA families in our database. We currently have 850 that we download from Wikipedia and redisplay on our own web pages as any new edits are made. This system allows expert RNA biologists to update the information in Rfam easily by editing Wikipedia. We were surprised by just how many improvements come from non-scientist editors in Wikipedia. Some fix our grammar, others our spelling, and one particular editor fixed the format of all the *et al.* in our articles.

Andrew Su from the Scripps Research Institute also uses Wikipedia as a repository for scientific information. He leads the Gene Wiki, which is a collection of 10,000 Wikipedia articles about specific human genes. If you want to know something about the hormone human chorionic gonadotropin (hCG), then there is an article just for you. But does anyone really want to read about hCG? Well, it turns out that hCG can be used as an adjunct to anabolic steroids. When Major League Baseball player Manny Ramirez was banned for 50 games for taking the drug, over 50,000 people viewed the Wikipedia article in just two days. Some of those readers thought the article could be improved, and in those two days there was a flurry of edits to it.

This shows how the public makes a real contribution to science through Wikipedia. If you find Wikipedia useful, why not try to improve it – you might teach the scientists a thing or two along the way.

Alex Bateman is a scientist at the Sanger Institute and a Wikipedia evangelist

---

GREG WILLIAMS_

Economics isn't about rational thinking

The cognitive and motivational processes that influenced your impulse purchase of a double-chocolate muffin at the coffee shop this morning may not be as straightforward as once thought. Traditional economic theory would say that the purchase was made because of the "utility" of the muffin, meaning that, at that moment you made the decision, it was based on a set of judgments derived from the way you allocate your resources across a range of goods and services in order to gain satisfaction.

One of the limitations of economics is that it is abstract. Its principles are a series of hypotheses that stress efficiency and idealised versions of human behaviour: it emphasises what people *ought* to do in order to achieve optimal outcomes. Economics is rooted in the ideal, not the human. The problem is that people don't always do what's most efficient. Psychological observation has offered us insights into what people actually do. But psychology and economics don't paint the whole picture: economic theory works well when describing large groups, and poorly when analysing individuals. Psychology can give valuable insights into individual behaviour, acting as a good descriptive tool, but it lacks coherence when it comes to theory.

Psychologists might point out that they were conducting tests long before economists, but neither discipline possesses pure science. The theory of utility might explain why you buy a muffin, but it stumbles when explaining why you gambled your inheritance or volunteered at a homeless shelter. Choice behaviour based on cost-benefit analysis leaves little room for ambiguity.

However, new ways of examining economic behaviour are being forged by a growing number of interdisciplinary research teams from the fields of neurobiology, experimental psychology, mathematics and social science. They are developing an approach based on biologically plausible models, using tools such as neural imaging, and analyses of how chemicals in the brain or neurons operate, rather than grand theory.

Using data gleaned from controlled economic experiments, departments of neuroeconomics – many barely five years old – are attempting to fill the gaps in our knowledge between what people should do, and what they actually do. The aim: to create an algorithmic model of human behaviour through a synthesis that blurs the border between the social and natural sciences.

The Center for Economics and Neuroscience in Bonn uses neuroimaging to investigate the neural basis for social and economic decision-making. It claims to be the first lab in Europe to scan the brains of two people taking part in an experiment simultaneously. Each subject was given a series of problems to solve and was rewarded with money for correct answers. However, one was given more money than the other. The subjects' brainwaves were recorded as they solved the problems and as they received their unequal rewards.

Scientists analysed data from the ventral striatum, the part of the brain most activated when a subject receives rewards. They found that the strength of the activation doesn't just depend on what an individual receives – it's made stronger or weaker depending on what others receive. The activation in the subject of the test who received a reward, but was aware that the other subject was getting more, was weaker. This suggests that, for the subject who was receiving less, comparison with what the other subject gained was more important than the sum received. The other insight: the more active the reward centre in the brain, the less rational thinking seems to play a role, which helps to explain fluctuations in financial markets and – perhaps – why you decided to buy a chocolate muffin as well as a raspberry one.

Greg Williams is executive editor of WIRED. *He blogs at* howwecreatevalue.com

ILLUSTRATION: PATRICK OLEARY

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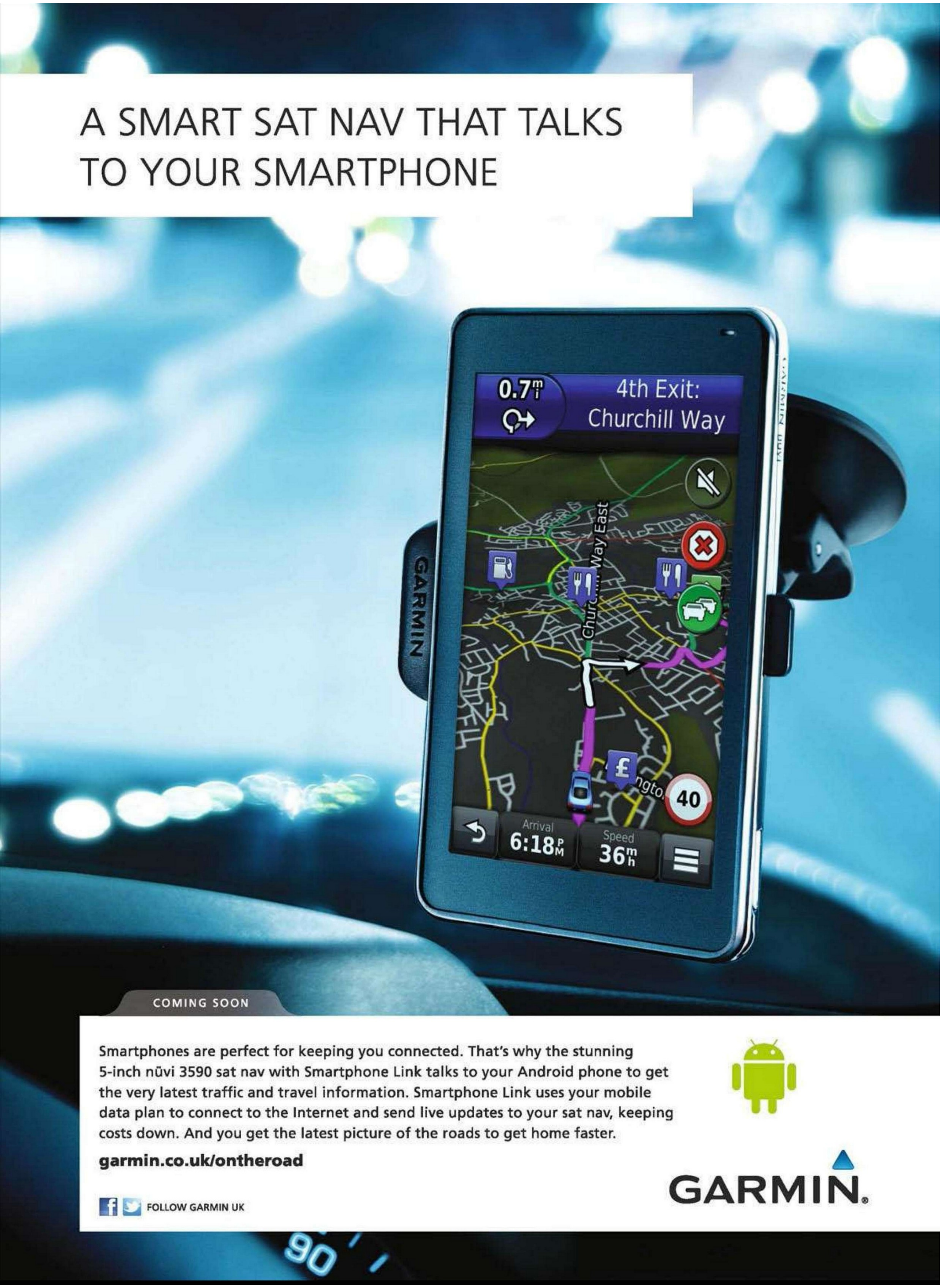

A SMART SAT NAV THAT TALKS TO YOUR SMARTPHONE

COMING SOON

Smartphones are perfect for keeping you connected. That's why the stunning 5-inch nüvi 3590 sat nav with Smartphone Link talks to your Android phone to get the very latest traffic and travel information. Smartphone Link uses your mobile data plan to connect to the Internet and send live updates to your sat nav, keeping costs down. And you get the latest picture of the roads to get home faster.

garmin.co.uk/ontheroad

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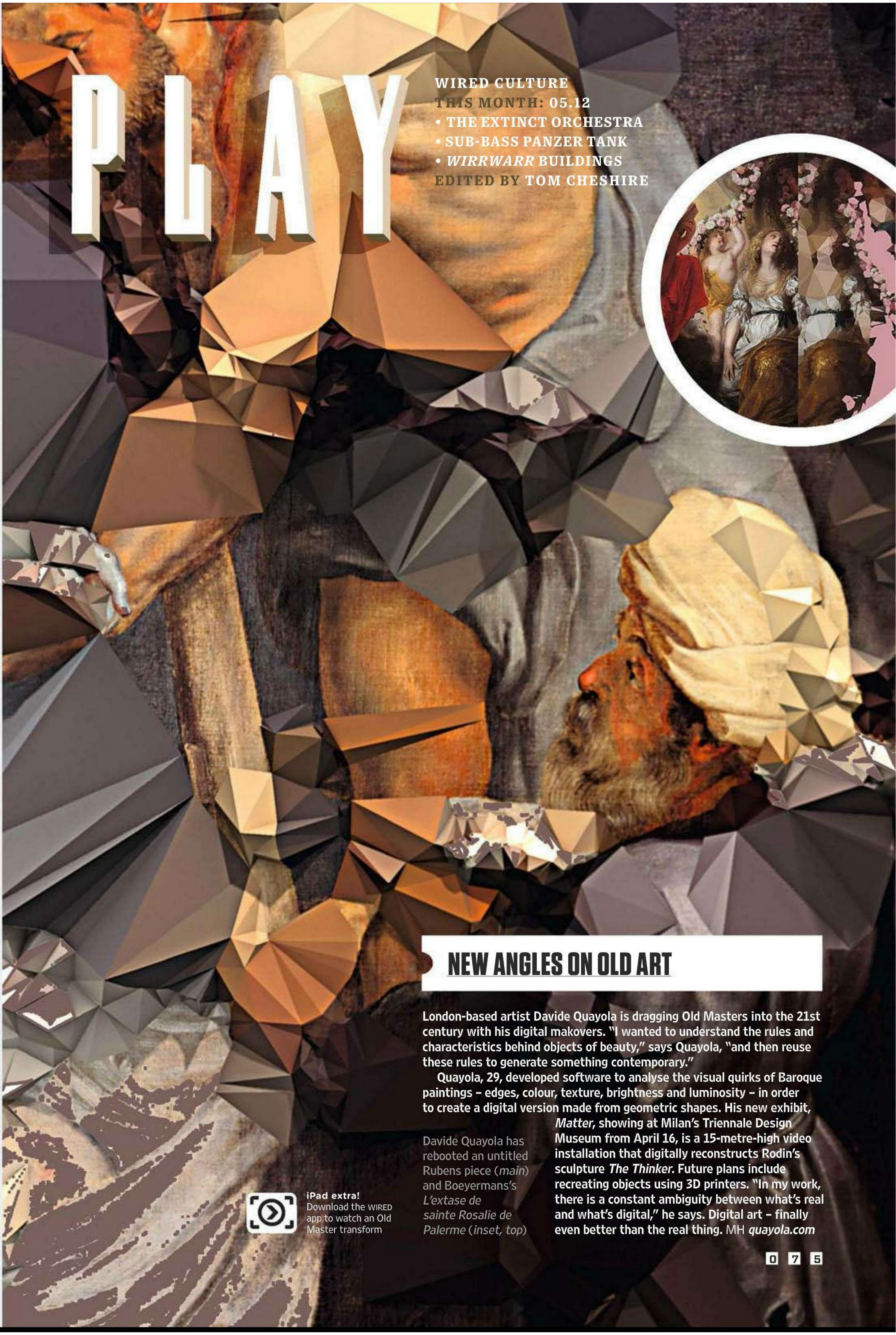
PLAY

WIRED CULTURE
THIS MONTH: 05.12
- THE EXTINCT ORCHESTRA
- SUB-BASS PANZER TANK
- *WIRRWARR* BUILDINGS

EDITED BY TOM CHESHIRE



Davide Quayola has rebooted an untitled Rubens piece (*main*) and Boeyermans's *L'extase de sainte Rosalie de Palerme* (*inset, top*)

NEW ANGLES ON OLD ART

London-based artist Davide Quayola is dragging Old Masters into the 21st century with his digital makovers. "I wanted to understand the rules and characteristics behind objects of beauty," says Quayola, "and then reuse these rules to generate something contemporary."

Quayola, 29, developed software to analyse the visual quirks of Baroque paintings – edges, colour, texture, brightness and luminosity – in order to create a digital version made from geometric shapes. His new exhibit, *Matter*, showing at Milan's Triennale Design Museum from April 16, is a 15-metre-high video installation that digitally reconstructs Rodin's sculpture *The Thinker*. Future plans include recreating objects using 3D printers. "In my work, there is a constant ambiguity between what's real and what's digital," he says. Digital art – finally even better than the real thing. MH *quayola.com*

iPad extra!
Download the WIRED app to watch an Old Master transform

PLAY FILM

THE HOLLYWOOD FAME GAME

Who sunk your battleship? Mysterious aliens, according to *Battleship*, a sci-fi action flick out this month that's based on the popular game. Hollywood is mining board games for movie inspiration: Ridley Scott was reported to be taking Monopoly to the silver screen, an adaptation of Risk is under way, and Adam Sandler will soon star in a film version of Candyland, a board game popular in the US. For the first time, WIRED studios can exclusively reveal the films on our dream pre-pre-production list. TC

HUNGRY HUNGRY HIPPOS

Director: Sam Raimi
Synopsis: *Deep Blue Sea* meets *Out of Africa*, as emotionally repressed Englishwoman Keira Knightley travels to Kenya and falls for free-spirited genetic scientist Hugh Jackman. But can their love survive when Jackman's genetically modified hippos – more colourful, more intelligent and even more hungry – escape the compound?
Tagline: Hungry, hungry – for your brains

THE SETTLERS OF CATAN

Director: Peter Jackson
Synopsis: An English-language version of the art-house hit *Die Siedler von Catan*, this is a majestic, sprawling epic in eight parts, documenting the settlement of the hexagonal world of Catan, which looks similar to New Zealand. Andy Serkis plays a motion-captured version of Andy Serkis.
Tagline: Even longer than the board game

CRANIUM

Director: Christopher Nolan
Synopsis: Joseph Gordon-Levitt is an astronaut who lands on the mysterious planet Cranium and is promptly attacked by creative space cats, word worms and data heads. His goal is Cranium Central, the planet's capital, but can he separate reality and sensosketch in this mind-bending movie? No one understands anything.
Tagline: The film for your whole brain

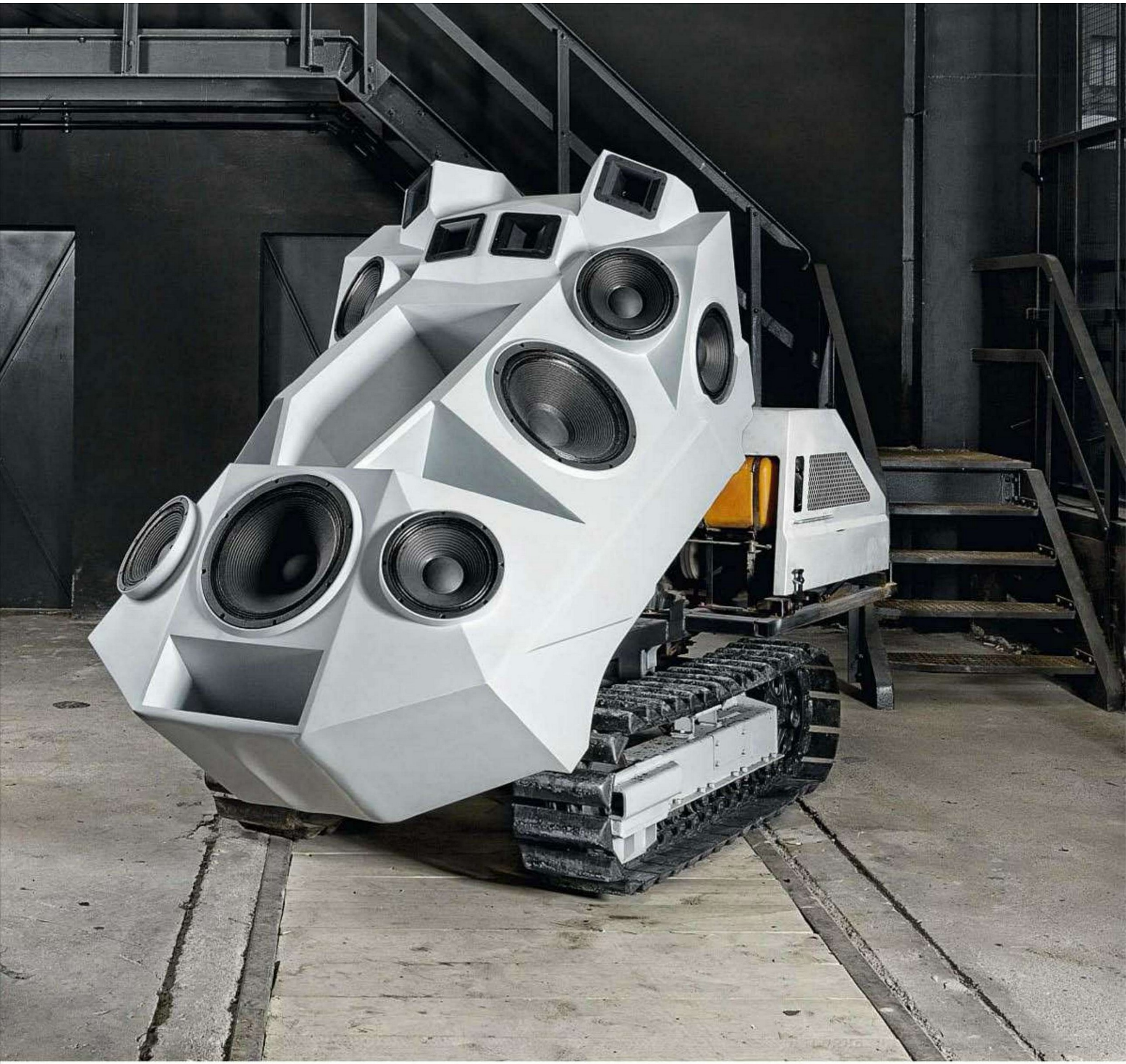
PLAY MUSIC

Audio assault

With 40,000W and 13 speakers, this tank really bombs the bass

Nik Nowak's Panzer is no ordinary tank: its 13 huge speakers can be raised hydraulically for an ear-splitting sound display. It's a massive, 40,000-watt mobile sound system – but it doesn't play club music. "People see the tank and expect techno," says Nowak, a 30-year-old sound artist. "But what they get is a pretty rough, primal soundscape. It's like an abstract poem, but more violent."

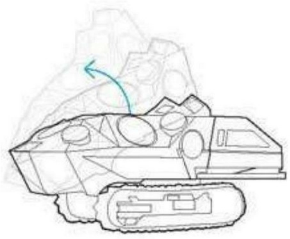
PHOTOGRAPHY: THOMAS HANNICH.
ILLUSTRATION: BRIAN WALLINE



Nowak composes the music himself, using sub-bass frequencies that – at 25hz – are bordering on the fringes of human hearing, particularly for adults. His aim is to recreate the intense, physical reverberations one experiences inside a club, if not the tunes themselves. "I'm someone who went clubbing often," he explains, "and those low frequencies affect your body in a very extreme way. The kick-bass – it really feels like your ass is being hit."

Berlin-based Nowak says he first became intrigued by sub-frequencies aged 14, when a gun went off beside his right ear. The hearing in that ear was damaged, and ever since he has found it irritating to listen to any high-pitched noise. "But when I'm in the studio, I'm working with bass frequencies that have a clear separation from higher sounds – and so I don't get that irritation. So that's why I'm interested."

Nowak has performed with the Panzer in his art studio, a gallery, an outdoor music festival and even a TEDx conference in Berlin. He likes the idea that he has transported these violent sounds from their usual club context and into external society. "A club is like a temporary anarchistic zone," he says. "Through extreme acoustics, a club changes the way you perceive things. And to build this tank was to bring that experience into the world outside." **Patrick Kingsley** *niknowak.de*



The tank is 150-250cm high, 350cm long and 140cm wide

IN THE NEXT ISSUE OF

ON SALE MAY 3

WIRED

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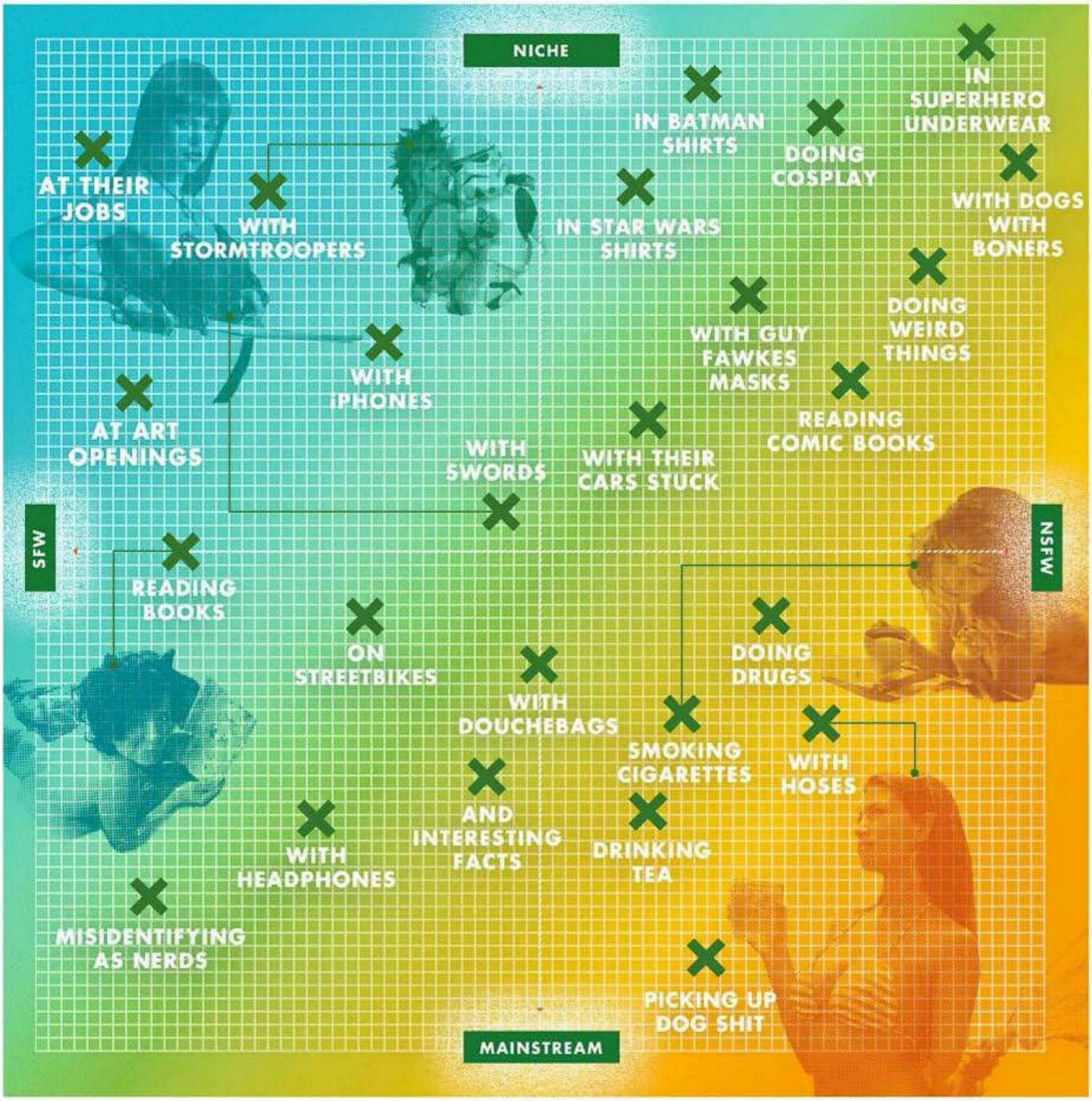
Hot chicks in a chart

"Hot chicks doing X" is a surefire formula for photoblogs to win page views. But there's no rule for what "X" can be, so we found out for you. TC



MUSIC: WEB GOES POP

HTML5 didn't kill the video star: the fifth generation of the ubiquitous web language is rejuvenating music videos online. "It's been a game-changer for me," says Chris Milk, who regularly uses the web as a canvas for his videos. Here are three worth watching. MV

OK Go, "All is Not Lost"
The band's latest – in a long line of viral videos – is a mesmerising human kaleidoscope dance, performed with the Pilobolus modern dance troupe. *allisnotlo.st*

Sour, "Mirror"
The Japanese band's video for the song "Mirror" is completely personalised. Viewers sign into Facebook and Twitter, integrating their own content. *sour-mirror.jp*

Aaron Koblin/Chris Milk, *Rome*
Milk and Koblin turned the Chrome browser into a console that lets you move objects with your mouse and steer through the 3D landscape in real time. *ro.me*

ILLUSTRATION: KELLI ANDERSON

PHOTOGRAPHY: LEON CSERNOHLAVEK

SEARCH THE METAPHORICAL GOOGLE

THIS MAGAZINE IS A BICYCLE
Results for "WIRED" on YossarianLives!

- ● Bicycle
- ● Bus
- ● Brain
- ● Battery
- ● Cup
- ● Petrol

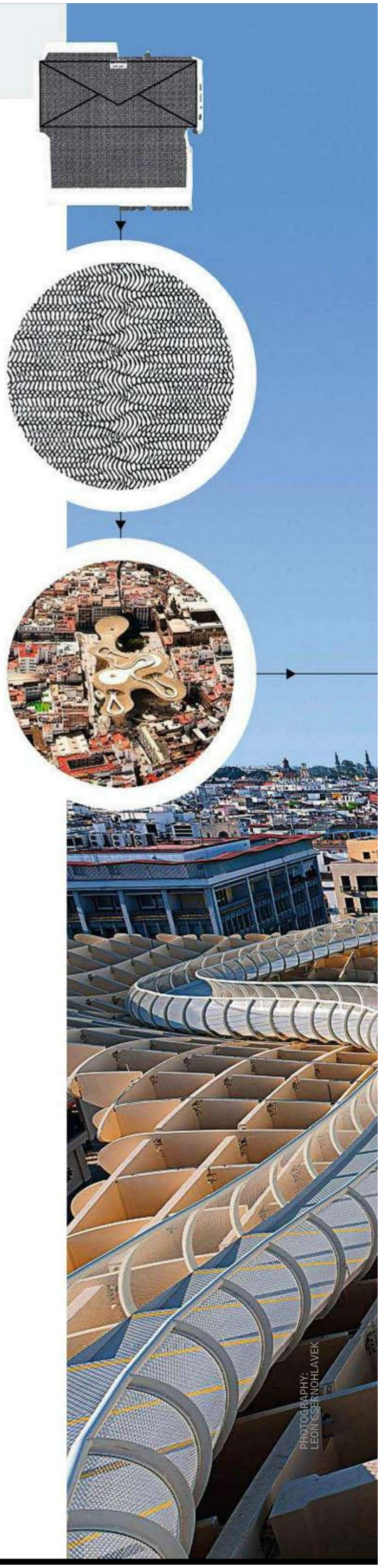
Love, according to a Google search, is a Wikipedia entry, a relationship calculator and a magazine. Try the same word on YossarianLives!, a "metaphorical" search engine which goes live this summer, and you get "river", "grace" and "clutch". "Love is not a river," says J Paul Neeley (*above, right*), cofounder of YossarianLives! "But metaphorically, there's a flash of insight – love flows, love is ever-changing, love is difficult to control, has a source... all the attributes of a river that help us to see love in a different way."

According to Neeley, 33, traditional search gives us access to knowledge, but "tells us only what the world already knows", – a catch-22 that led to the site's name (Yossarian is the main character in Joseph Heller's book). The site's algorithms return distant but potentially related results to offer a new perspective, so a search for "emergency room" may return a picture of an F1 pit crew. (See above for more results.)

Neeley met cofounder Daniel Foster-Smith (*left*) when they were studying design at the Royal College of Art. They created YossarianLives! in February 2011 with Katia Shutova (*centre*), a computer scientist at Cambridge University, and have since won funding from Deutsche Bank and Imperial College, along with a place at Seedcamp London.

The trio started by setting two computers to work on the British National Corpus, parsing the attributes of each word; a process which is, not surprisingly, ongoing. "The algorithms were reading Jane Austen the other day, and they started returning results from that language and time period," says Neeley. "Like a friend who keeps referencing a particular movie they like."

The intention is to present results just beyond a user's knowledge and at a distance from the original term. "Too close together, it's obvious," says Neeley. "Too far, it can appear completely random. There's a sweet spot where it gives you that flash." TC *yossarianlives.com*



Designed on an envelope

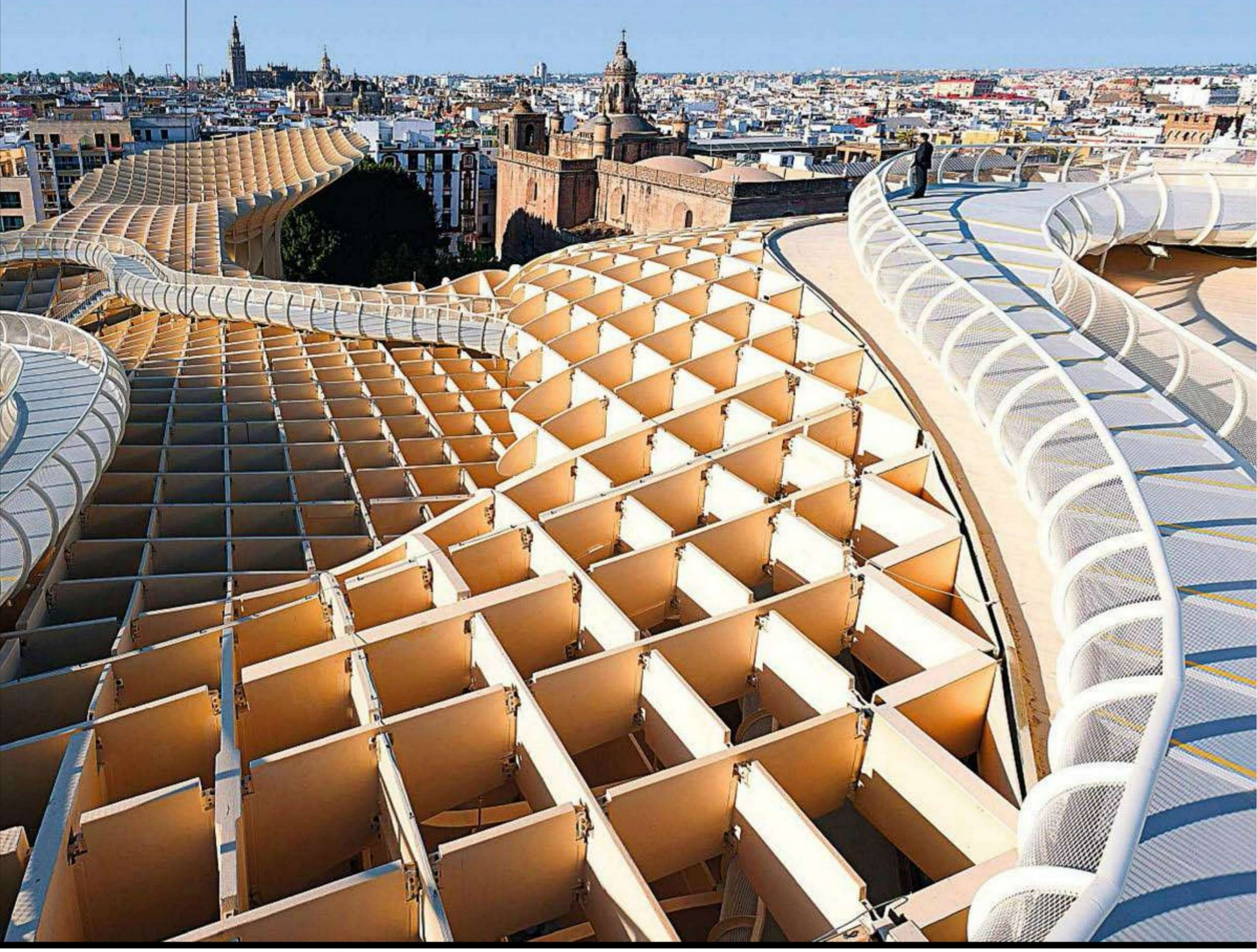
Those security patterns that protect your PIN? They've inspired buildings

Envelopes containing PIN numbers are typically lined with black and blue patterns: some are thickets of letters, others swirl like topographic maps. For most of us, they're quickly forgotten; but for architect Jürgen Mayer H, they are a source of inspiration. He documented many of his favourites in his book *Wirrwarr* (Hatje Cantz). ("Wirrwarr" is German for "confusion".)

They are so banal we don't really know what to call them – "information camouflage," suggests Berlin-based Mayer, who has amassed hundreds of examples. "It's an easy thing to collect," he says. "They come to your house every day." Their origin is obscure (Mayer traced them as far back as a German printer's catalogue from 1913); functionally, he says, "there's no rule as to how confusing they have to be" to deter prying eyes. His design for the Court of Justice in Hasselt, Belgium, uses walls of these patterns as a *brise soleil*, or architectural sunshade; his Metropol Parasol in Seville looks like a giant *moiré* grid.

The patterns themselves may be meaningless, but they are not without significance. "This is one of the last moments where data control is still visible, before it moves into the invisible, virtual, digital world," says Mayer. "It seems important to capture that moment a little longer." **Tom Vanderbilt** *www.jmayerh.de*

The overlapping grids printed on an envelope inspired Jürgen Mayer H's design of the Metropol Parasol in Seville, Spain



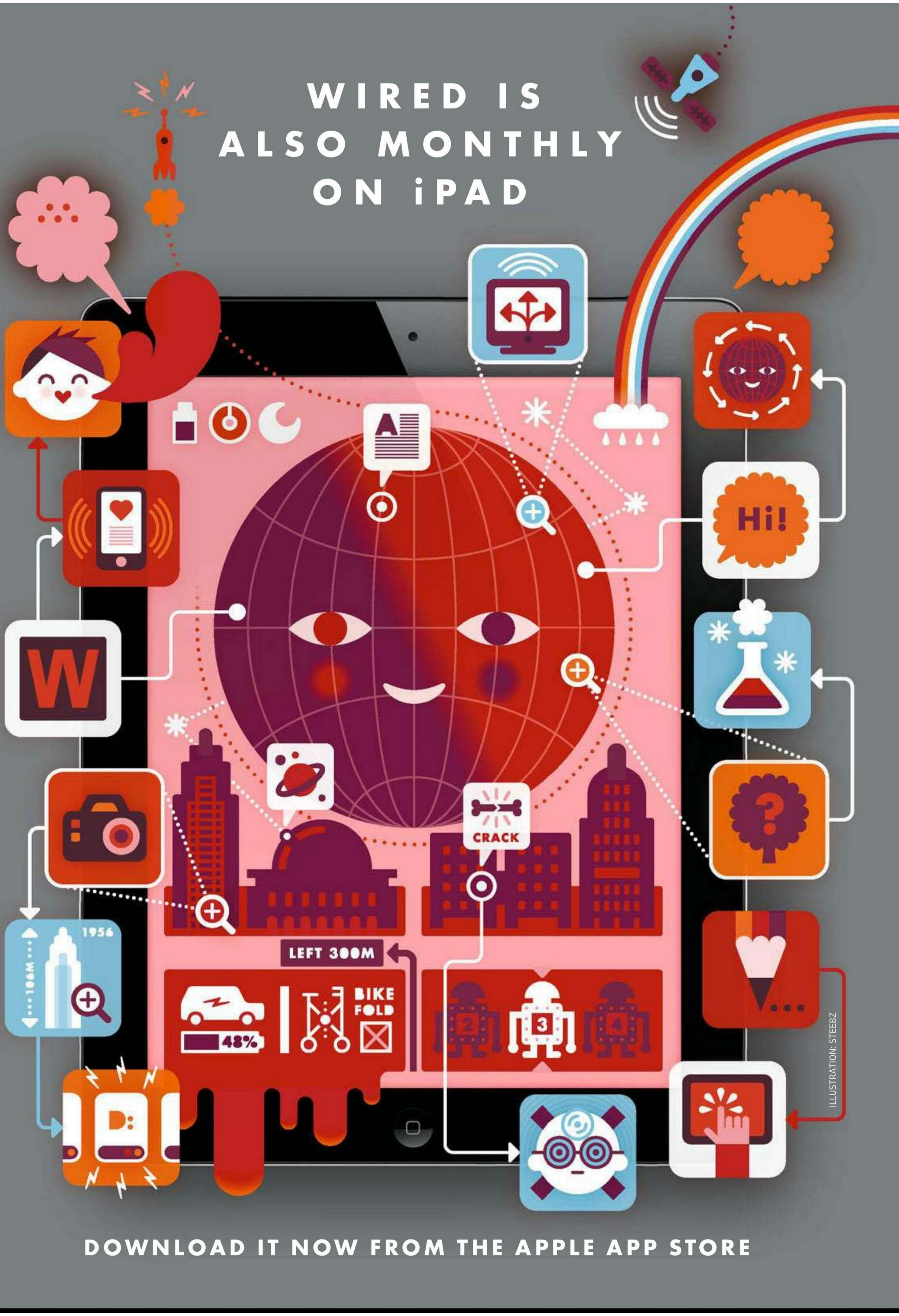


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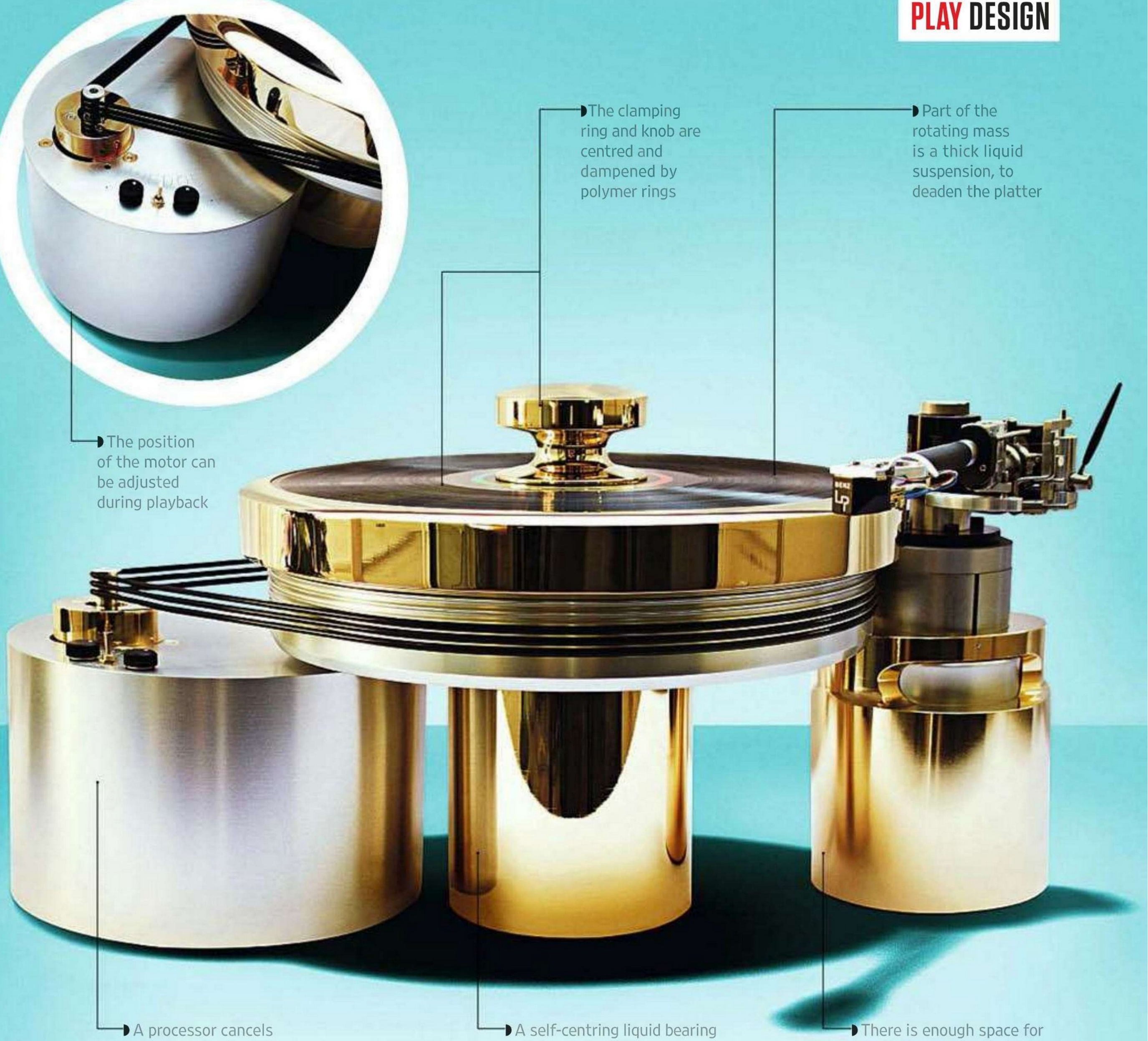
ILLUSTRATION: STEEBZ



The clamping ring and knob are centred and dampened by polymer rings

Part of the rotating mass is a thick liquid suspension, to deaden the platter

The position of the motor can be adjusted during playback

A processor cancels distortion and locks the motor to the desired speed

A self-centring liquid bearing permits only steady rotation and doubles as suspension

There is enough space for four towers, holding four tone-arms of any type

Space spinner

An engineer who has planned Nasa missions to Mars has now designed a turntable

Record players, meet rocket science: "I applied the same methods of design and engineering analysis that I would use in the development of a spacecraft or an aircraft," says Aleks Bakman, 57-year-old designer of the One Degree of Freedom (Onedof) Turntable.

The Nasa-medallion-winning aerospace engineer originally envisaged the turntable as a scientific instrument to read analogue data, but realised he could make a music player that "would match the quality of the musical instruments used to perform music". The Onedof's platter allows only one degree of freedom, around the vertical axis. A film of oil – rather than the usual spring – suspends the bearing, eliminating unwanted resonance and distortions, and the drive equalises noise from the motor in the same way that noise-cancelling headphones work.

The parts come from the Colorado factory used by Lockheed Martin Space Systems

At $150,000 (£100,000) plus shipping, the turntable is marginally less expensive than actually going to space (cost of a Virgin Galactic ticket: $200,000). But it's still cheaper than Bakman's usual going rate: "The 2005 flight to Mars cost American taxpayers $720 million – I helped to develop the rocket, launch tower and spacecraft... I do not expect a profit from the sales of the Onedof. I built it in order to make a statement: this is what I can do." We'll take two and a mixing desk, thanks. **TC** *onedof.com*

PLAY DESIGN

Roars remade

Want to know what a 50-million-year-old walking whale sounds like?

Last February, designer Marguerite Humeau (*right*) sent several scientists an email: “I’m contacting you because I want to create an orchestra of extinct animals.” Since then, the Brittany-born, Hoxton-based designer has collaborated with more than 100 palaeontologists, zoologists, biologists, speech therapists, radiologists, vets, surgeons and sound engineers to reconstruct the vocal tracts of three creatures – a mammoth, an entelodont (an ancient pig) and an ambulocetus (a whale that walked 50 million years ago, *shown right*) – for an exhibition. She began with the mammoth.

Bernard Buigues, a French explorer who searches Siberia for woolly mammoth carcasses, gave her MRI scans he had taken of a 10,000-year-old mammoth. Humeau combined these with fossil data from Digimorph.org to sketch a design that she converted into a digital 3D representation, then realised in polyurethane foam using a computer numerical control (CNC) machine. Fitted with silicon membranes to simulate vocal cords, the finished heads, larynxes and windpipes are hooked up to an air compressor; the installations play a score composed by Julien Bloit, a researcher at IRCAM, a centre for the science of music and sound. “I’m not only recreating a shape, but also the data that has disappeared – we’ll never be 100 per cent sure this is accurate,” says Humeau. “But when I heard it roar, it felt real.” **TC** Politique-fiction *opens at Cité du Design, Saint-Etienne, on May 3 and runs until January 2013. marguerite humeau.com*

A CT scan of an Asian elephant helped reconstruct a mammoth’s vocal tract

iPad extra!
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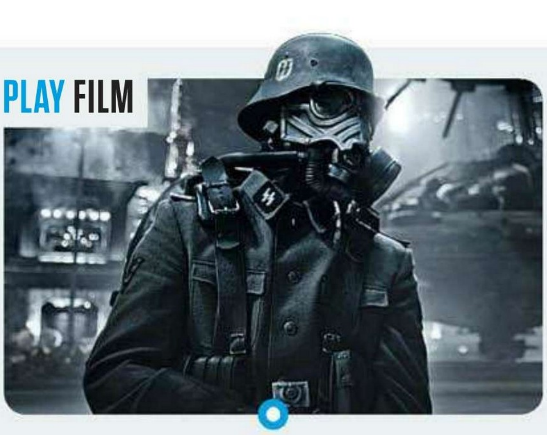
PLAY FILM



IRON-CLAD INVESTMENT

Iron Sky envisions a ridiculous future: in which Nazis fled to the dark side of the Moon during the second world war, only to return in 2018 with a space fleet (the “Meteorblitzkrieg”). Given the Finnish/German/Australian film’s premise, it’s no surprise that director Timo Vuorensola and producer Tero Kaukomaa came up short with traditional fundraising. So they turned to their fans, going beyond standard crowdfunding to “crowd investing” – inviting members of the public to become shareholders. A €20,000 (£16,700) investment secured an associate producer credit and, if the film succeeds, might even earn a return.

About 200 investors – on top of the 10,000 fans who participated in crowdfunding – finally raised more than £515,000. And although this sort of micro-investment profit-sharing is restricted by US law, Kaukomaa believes it’s the future.

PHOTOGRAPHY: ALEX LAKE

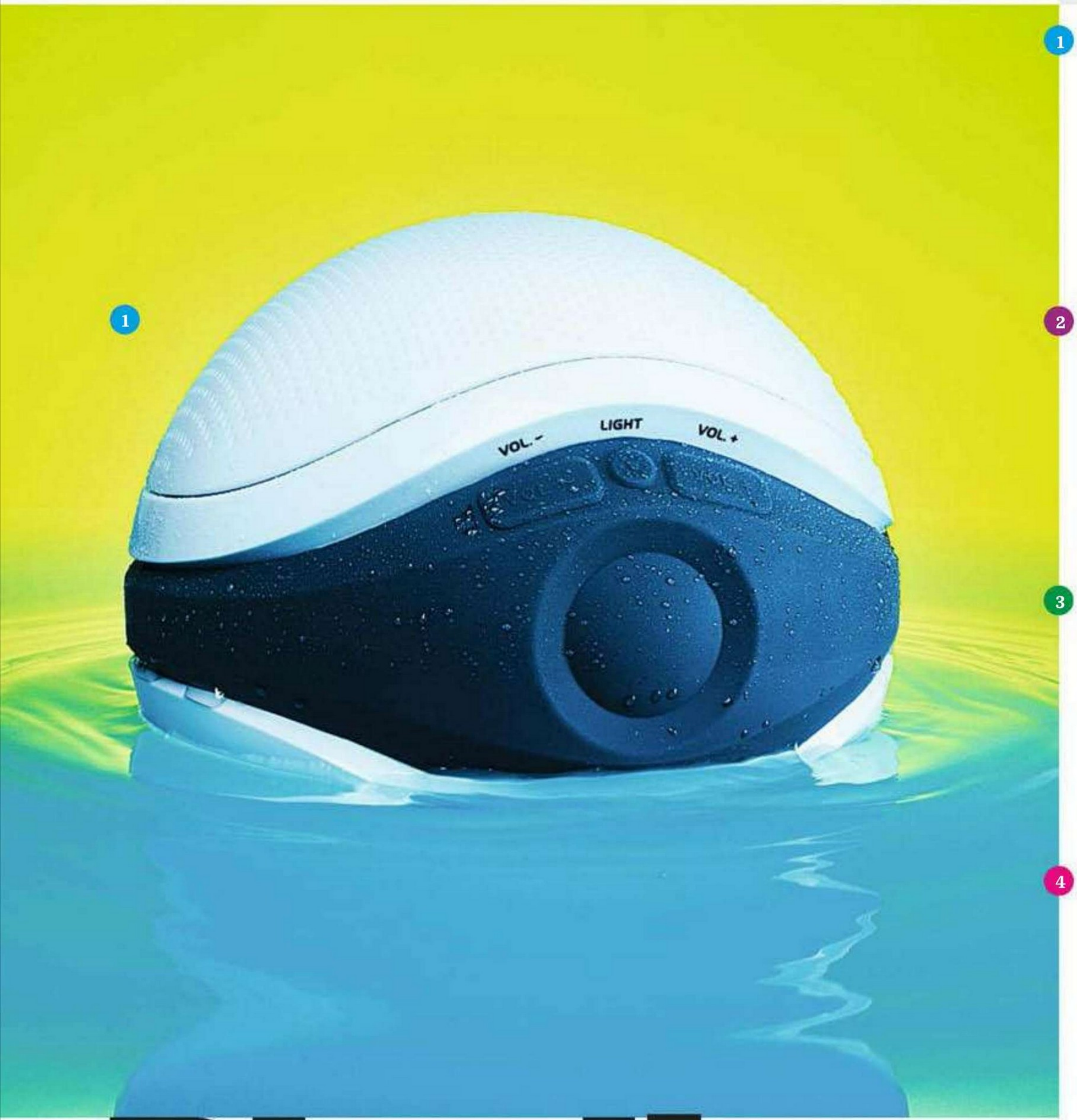
Even so, it's not something any film can accomplish; *Iron Sky* was able to attract interest thanks to its fervent fanbase from previous project *Star Wreck: In The Pirkinning*, released as a free download in 2005 before being issued on DVD. Kaukomaa and Vuorensola crowdsourced location ideas and spaceship designs – in one scene set outside a cinema, an array of fan-made film posters appeared. "It's not enough to just make a film, tease it and put it out there," says Kaukomaa. "You should create a community."

Stephen Kelly **Iron Sky** ***is released on April 4. ironsky.net***

The Nazi villains will also appear in comic books and a video game

The Finnish head of CGI claims a passion for "huge space battles"

1



Playlist

CULTURAL PICKS OF THE MONTH
05.12

1 **FLOATY TUNES**

Take your hot-tub party to the next level by throwing in an Audio Unlimited PoolPOD floating speaker. Packing a 7.5cm driver, it connects to a 900MHz wireless transmitter dock safely on dry land, up to 45m away. $99 *amazon.com*

2 **OLIVIA THIRLBY**

Thirlby is a name to watch – she stars in US indie-flick *Nobody Walks*, showing at Sundance London. It's the first time Robert Redford's 34-year-old film festival has crossed the Atlantic. Held at the O2, April 26-29 *sundance-london.com*

3 **HANDY TOOL**

The Gerber Gear Steady Tool has a mini-mount for your smartphone or DSLR camera – and when you're finished taking snaps, it'll help you catch and skin dinner with its three knives. Or just open up a can of beans... £79.99 *alloutdoor.co.uk*

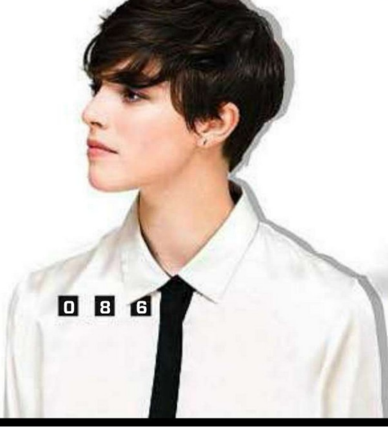
4 **MASHUP MARFO**

Look out for Clement Marfo & The Frontline on the festival circuit this summer. The London-based collective mix metal, hip-hop, euphoria and grime with pop hooks. The new single, "Mayhem", featuring Kano is available now. *clementmarfo.com*

5 **DESIGNER BACTERIA**

German artist Jannis Hülsen uses bacteria to upholster his stools. His book *Xylinum* shows how xylinum bacteria, which produces artificial cellulose, can be used in soft furnishing. You'll never vacuum up again. *jannishuelsen.com*

2



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4

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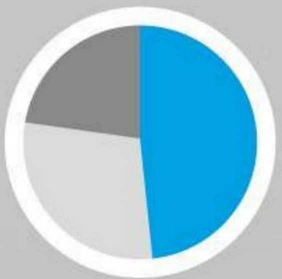
PHOTOGRAPHY: WILSON HENNESSY. WORDS: DAN SMITH

V60 IN DETAIL STATS+ FIGURES

CHARGING TIMES

- ● 6A Fuse – 7.5 HRS
- ● 10A Fuse – 4.5 HRS
- ● 16A Fuse – 3.5 HRS



PURE, HYBRID AND POWER MODES

The three modes combine with one overall effect – a power transition so smooth and economical you don't even notice it – you just drive

THIS MONTH WE GET UNDER THE SKIN OF THE NEW V60 DIESEL PLUG-IN HYBRID. FIND OUT HOW IT COMBINES EFFICIENCY WITH EFFORTLESS POWER

PHOTOGRAPHY: BENEDICT REDGROVE

THE NEW V60 DIESEL PLUG-IN HYBRID CAN RUN FOR UP TO 1,000KM BEFORE REFUELLING. AT THAT RANGE YOU COULD DRIVE FROM PARIS TO PRAGUE ON A SINGLE TANK OF DIESEL

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As one would expect from the design team's very personal approach (as highlighted in WIRED 04.12), it also makes a virtue of innovation, convenience and style. Everywhere you look, from the wheels up, there is something new – either tweaked or completely original to the car, and always an improvement. It's not just the engine and the interior, either. For instance, using your smartphone or via the car's setup menu, you can preheat or precool the car while it is charging.

This means you don't have to get into an oven in summer or a freezer in winter, and suffer while the air conditioning catches up. There's more to this than convenience. Batteries suffer in cold and warm weather, but preheating or cooling lets you use electric drive from the get go. This has a knock-on effect, improving fuel consumption and CO_2 emissions, while extending the electric drive-range by keeping the battery within the optimum temperature range.

That's just one example of the new thinking behind the V60. The net result of this state-of-the-art technology, combined with Volvo's deep understanding of what we want and what we need from our cars, is something that is greater than the sum of its parts – and in every sense a real trailblazer.

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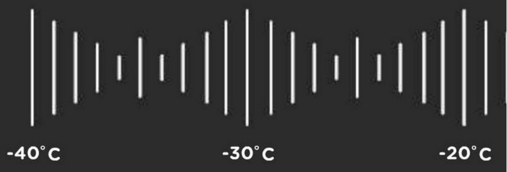
BATTERY PACK: STATE-OF-THE-ART TECHNOLOGY

The designers took a bold new approach to the battery

- 11,2kWh lithium-ion
- 8kWh available for powering the car
- Housed under the load floor – only a minor effect on loading capacity
- Made from 200 cells (10 modules x 20 cells)
- Engineering focus on long life span, safety, compact size and high energy density
- Integrated water-cooling
- Integrated computer monitors and compares the temperature and charge level in each cell for maximum performance and safety

BATTERY TEMPERATURE

Keeping the temperature stable is critical to battery efficiency



PRE-CLIMATE CONDITIONING FOR COMFORT AND EFFICIENCY

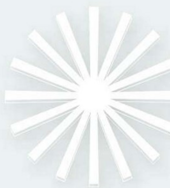
From the deepest Scandinavian winter to the baking heat of the Spanish sun, pre-climate conditioning keeps everything ready to go

- Possibility to preheat or precool the passenger compartment while charging
- This means that more battery capacity can be used for powering the car
- Pre-climate can be programmed via the car's setup menu
- Can also be programmed using a smart phone application

Defrost windows and rear mirror

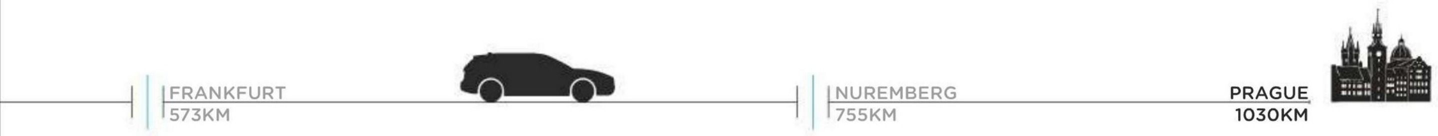
Pre-cooled battery

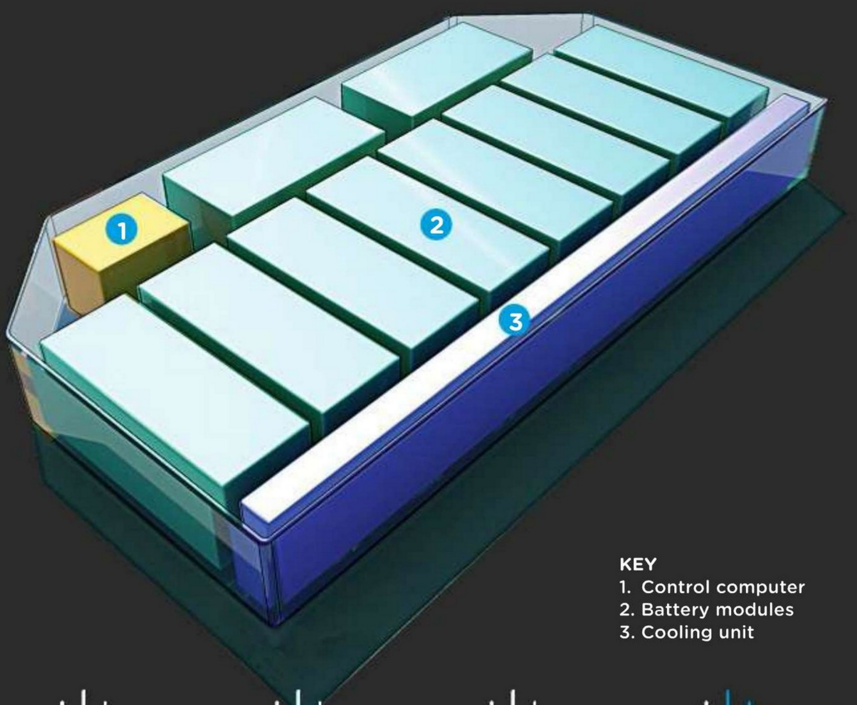
Pre-heated cabin



Pre-cooled cabin

Pre-heated driver and passenger seats

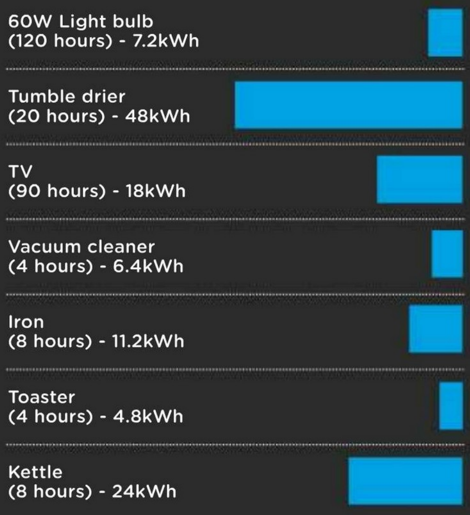




KEY
1. Control computer
2. Battery modules
3. Cooling unit

EFFICIENCY IN PERSPECTIVE

(Based on average usage over one month)



EYE-CATCHING FIGURES

In the end it all comes down to numbers. These are some of our favourites – but for the full story you'll have to try it for yourself

45	3.5	49	400	50
The diesel tank's capacity in litres	Time in hours for a complete recharge	Grams of CO_2 per km in hybrid mode	Volt battery, long-lasting, highly efficient and compact	Kilometre range in Pure mode

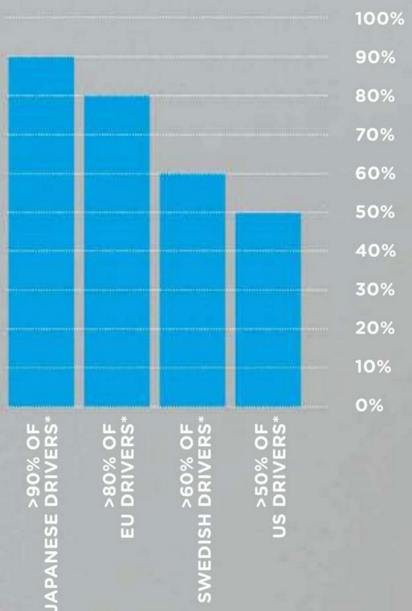
ILLUSTRATION: LIAM KEATING

WIRED PROMOTION

CLEANER SAFER GREENER V60

50KM RANGE WORLDWIDE

Right around the world, the average driver travels 50km or less per day. In Pure mode, the V60 is powered solely by its electric motor as much as possible. If the battery pack has been recharged with electricity from renewable sources, its range is up to 50km with no CO_2 emissions from the tailpipe, and minimal impact on the environment. Now that's clean.



DESIGNED WITHOUT COMPROMISE, THE NEW V60 PLUG-IN DIESEL HYBRID IS THE FIRST OF ITS KIND IN THE WORLD – A CAR FOR TOMORROW, THAT'S READY FOR TODAY

*DRIVING 50KM OR LESS PER DAY

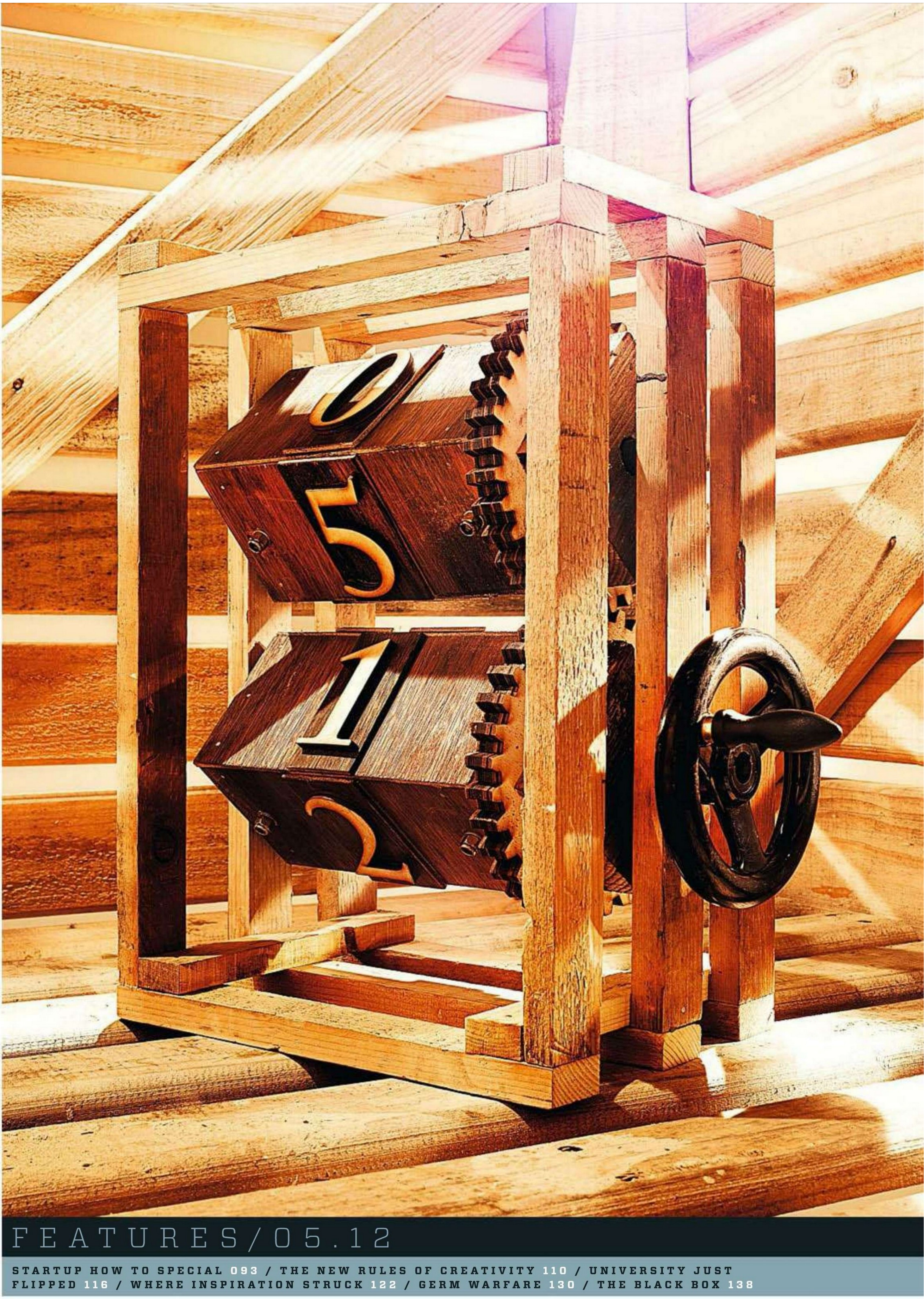


ILLUSTRATION: JOONHO KWON, BUILT USING RECLAIMED FLOORBOARDS, 4MM AND 6MM PLYWOOD, AND A PLASTIC AND METAL HANDWHEEL. THE LETTERS, NUMBERS AND GEARS WERE LASER-CUT

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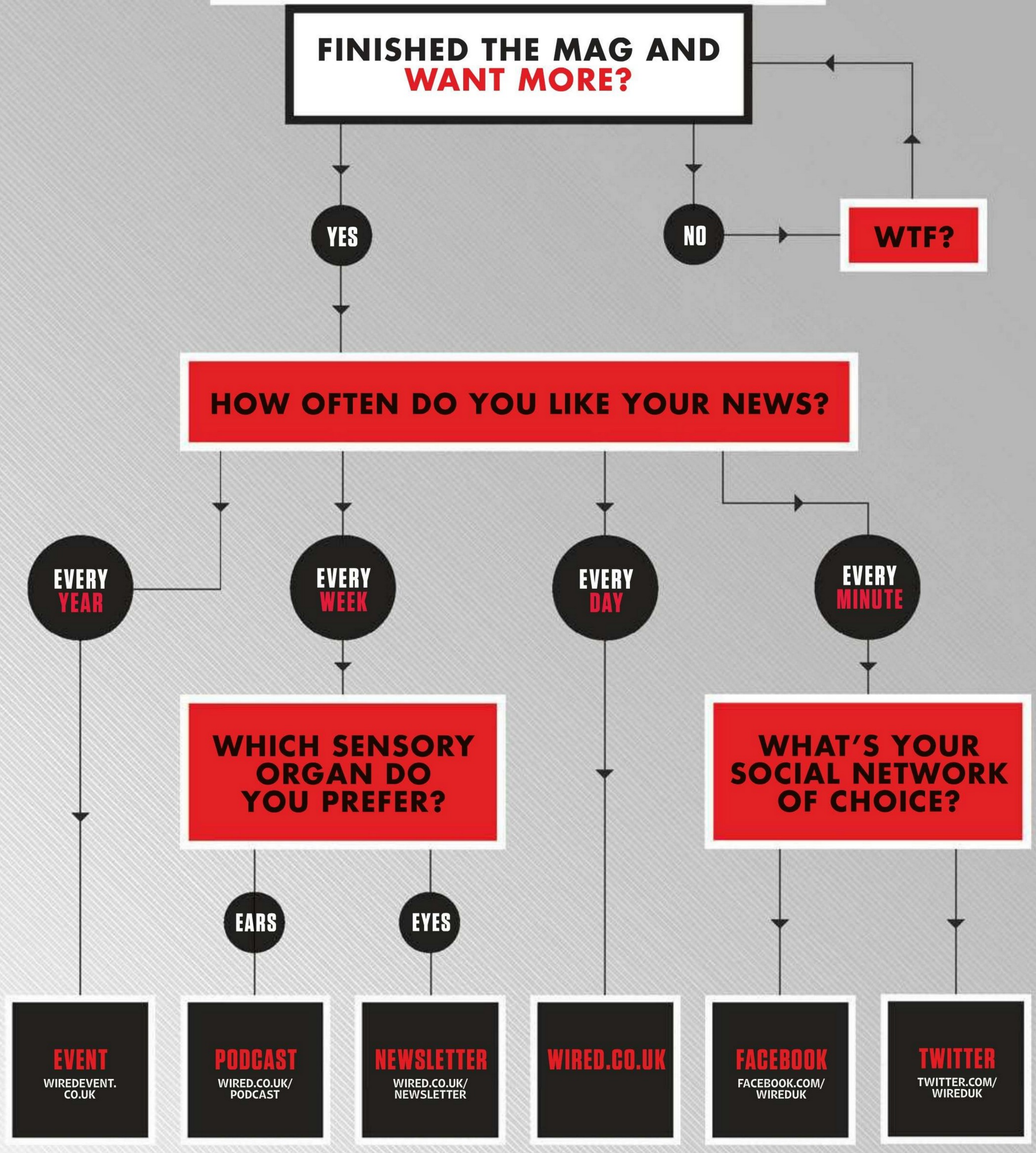
WIRED.CO.UK



FINISHED THE MAG AND **WANT MORE?**

YES

NO

WTF?

HOW OFTEN DO YOU LIKE YOUR NEWS?

EVERY YEAR

EVERY WEEK

EVERY DAY

EVERY MINUTE

WHICH SENSORY ORGAN DO YOU PREFER?

WHAT'S YOUR SOCIAL NETWORK OF CHOICE?

EARS

EYES

EVENT
WIREDEVENT.CO.UK

PODCAST
WIRED.CO.UK/PODCAST

NEWSLETTER
WIRED.CO.UK/NEWSLETTER

WIRED.CO.UK

FACEBOOK
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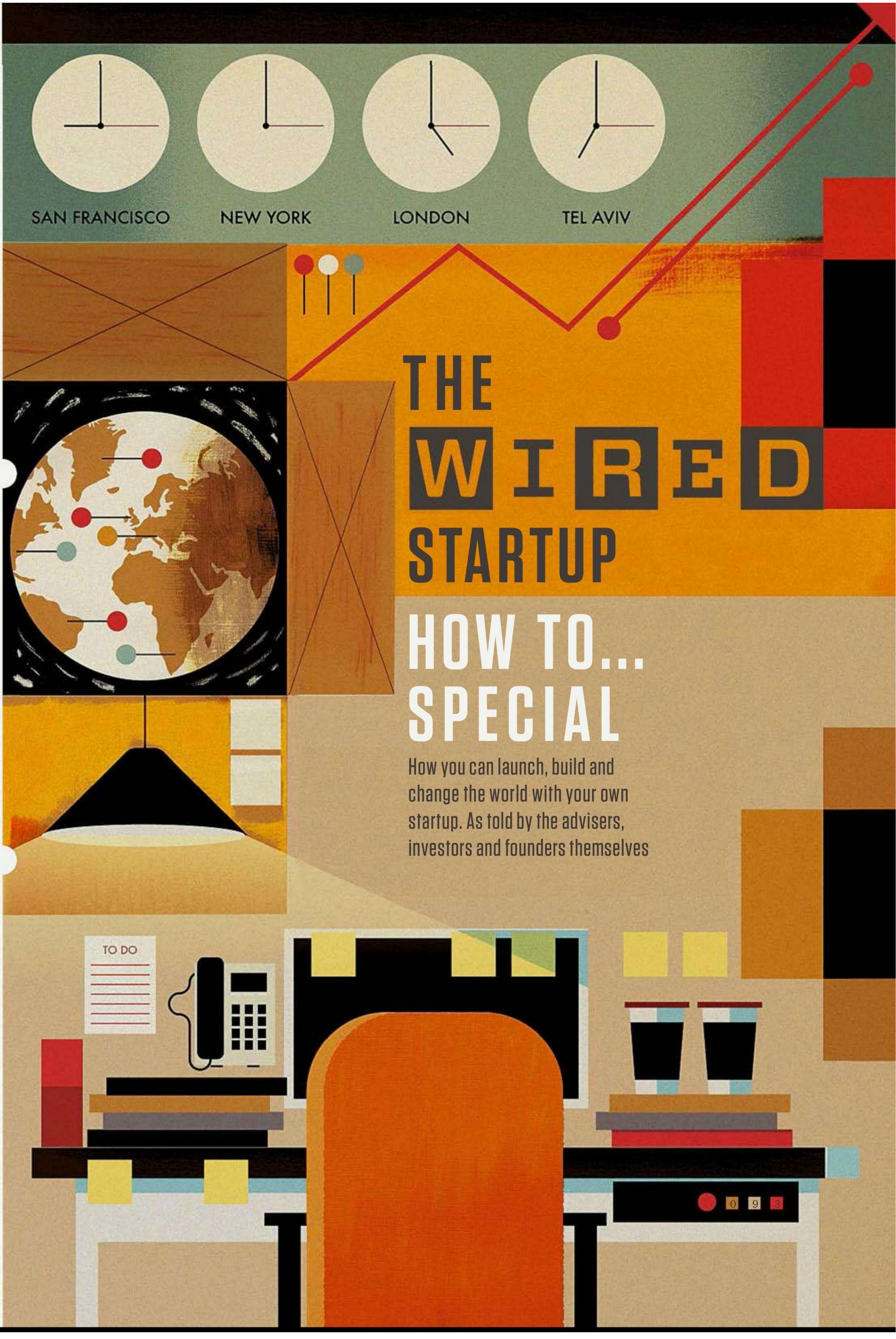


THE WIRED STARTUP

HOW TO... SPECIAL

How you can launch, build and change the world with your own startup. As told by the advisers, investors and founders themselves

ILLUSTRATION: MIKE LEMANSKI

INTRODUCTION

YOUR STARTUP'S MOMENT HAS COME

There's never been a better time to be an entrepreneur in the UK. Investors have zero-tax breaks, universities and corporates want to help you, and failure is an option – and often a valuable lesson. By *Sherry Coutu*

There's no doubt in my mind that this is the best time ever for a globally ambitious entrepreneur to start a business.

In the UK, we're making progress towards helping to develop and support our entrepreneurs. Since the 60s, Silicon Valley has been the most promising place to start a tech business, but in the last few years other candidates have emerged: New York, London and Berlin all have a vibrant tech cluster and are competing to attract the best talent. The knock-on effect of this is that other nascent clusters have had to up their game – and the only way they can do that is by making the entrepreneurs who come to them more successful. How good is that?

This geographic elasticity reflects how a key attribute to starting a business today is a willingness to travel to develop a network. Successful US-based entrepreneurs such as Joi Ito, Reid Hoffman and David McClure are conversant with a number of clusters across the globe because finding people who are the best at solving a particular problem involves constructing global plays. Entrepreneurs and investors who do that, win.

A good example of this cross-border curation of talent is a US company I've invested in, Bonobos, which makes men's clothes. The founder wanted angels with varied areas of expertise – databases, retail, fast international rollouts and fashion. He hand-picked investors from the US and UK to help him in those areas. Another company I'm involved with, Brainient, chose investors from the US, UK and Europe because each would draw on their hubs for expertise. New Energy Finance, Last.fm and Spotify are great examples of businesses that tapped people in separate, distinct networks at the same time. Don't connect the dots – connect the hubs.

Another helpful development for the UK ecosystem is the improved tax incentives for angels. If they're the first investors in a business, angels will receive a 50-per-cent tax break and, if they invest in 2012, will never face capital-gains tax. The Seed Enterprise Investment Scheme is a game changer as the maths makes it a no-brainer for higher-tax-rate earners.

At the same time we're going to have to be vigilant that new angels are thoughtful about the way they invest. They need guidance. After I floated my company, Interactive Investor International, in 2000, one of the things that helped me as a novice was that I had a number of very experienced angels who allowed me to invest with them and learn the ropes. The other side of this is that we need to avoid the really experienced angels oversubscribing the great deals – there needs to be room for new money.

Corporates are being more thoughtful about what they can do. Google is involved in Tech City, and assigns mentors to startups. Microsoft has its BizSpark programme and IBM has a number of initiatives. These schemes help us all by forming communities of entrepreneurs, which gets everyone up the learning curve faster.

Universities are also an important part of the equation. In the US, MIT and Stanford led the way. In the UK, many universities have their own startup competitions. Seedcamp has been working with UCL, Cambridge has been working with Springboard, Imperial has the Imperial Incubator and many universities involve alumni with projects in development at the university.

In the UK we often talk about failure but we need to consider what we're doing in testing hypotheses. If you test a hypothesis and it doesn't work, move on. Maybe it's a success, maybe not. The important thing is to learn from it. Recently there was some research from the Kauffman Foundation in the US that revealed that, among the 500 fastest-growing companies, the average age of their founders is 40. We often focus on younger entrepreneurs, so it's worth remembering that you might found something when you're 40. And, in order to have something successful, you'll need to have tested hypotheses at other companies. Another thing I found intriguing was that, despite

No. 19

UK's global ranking, out of 183, for ease of starting a business (*data sources: p154*)

popular opinion, only 14 per cent of the fastest-growing 500 US firms are funded by venture capitalists. The idea of VCs as necessary for growth is wrong – most startups have not turned to them for funding.

The key thing is to learn by doing. When your approach is one of testing hypotheses, you navigate it differently. Is a business that tests a hypothesis and pivots and then pivots and then pivots and then succeeds a three-time failure or a success? *Angry Birds* was Rovio's 52nd game. Do the first 51 make Rovio a failure or a success?

There are really big problems that we face today that can be solved only by entrepreneurs. My goal is to help work out what we do about the lack of scale-ups in the UK – we need to get the competition going not only on starting them up, but in scaling them up to billion-pound concerns. The talent here can rise to the challenge of solving the problems we face – and millions of jobs will be created by the companies that are founded to do so.

Sherry Coutu is an entrepreneur and angel investor

PHOTOGRAPHY: JAMES DAY

HOW TO...

RAISE ANGEL INVESTMENT

Angels fill the gap between cash spotted by friends and family and the investment of venture capitalists. Tom Hulme, entrepreneur, design director at Ideo and investor in firms such as Smarkets and Wonga, explains how to get his backing. Tom Cheshire

GET IN TOUCH

Sites such as Angel List (*angel.co*) and LinkedIn are a good way to find angels who invest in your sector. Once you're inside a group such as the Cambridge Angels, the network effect is powerful. "The bulk of work I do is through referral," says Hulme. "You get referred into that network, and then you can pitch to all the angels. And that process of referral means there's social equity on the table."

ANSWER THE QUESTIONS

When you meet an angel, you may be bombarded with questions. "You'll think, 'All that Tom cares about is the idea'," says Hulme. "But actually I'm doing it to find out about you – how flexible you are, how open-minded, how ambitious, whether you've got a team with a complementary skill set."

BUILD A TEAM

"I never invest before the team is in place," says Hulme. "And I stress test the relationships. Does everyone defer to one person? If you challenge one of them, do the others support?" And he's he's unlikely to invest in lone entrepreneurs: "Individuals aren't as motivated."

EARN YOUR STRIPES

Hulme prefers to invest in serial entrepreneurs, no matter how well or badly their first business went. "We live in a time where there's no excuse for not actually trying something. If you or I were at university again and decided that we wanted to be entrepreneurs, it would be unforgivable after that not to try something entrepreneurial."

...PITCH ME! #1

BARRY MALONEY, PARTNER, BALDERTON CAPITAL

We meet hundreds of entrepreneurs from around the world who want investment. It amazes us to see the same mistakes in their presentations...

- **Be honest.** If you don't know the answer to a question, it is usually best to say, "I don't know."
- **Keep your ideas simple.** Almost every startup overbuilds their initial proposition.
- **Don't be distracted.** IP, technology and patents are almost always irrelevant. If your idea is good, we can always work together to make it work.
- **Tell us what you think.** Not what you think that we want to hear.
- **Think** about your requirements realistically. Don't ask for more money than you actually need.
- **Tell your story.** But in fewer than 20 slides.
- **Convince us.** That you want to be rich, not famous. Fame chasers are bad news for investors.
- **Don't...** Forget to explain up front in simple terms what you're doing and how your idea is compelling.

HERE BE MONSTERS

PHOTOGRAPHY: SPENCER LOWELL

HOW TO...

CREATE A GLOBAL BRAND FROM THE UK

Michael Acton Smith's Mind Candy and its Moshi Monsters have colonised the web, reaching 60 million children all over the world – but only after surviving a disastrous beginning and a 'last roll of the dice'. By *David Baker*

On a page of issue 11 of *Moshi Monsters* magazine, Michael Acton Smith, CEO of Mind Candy and the man behind the Moshi Monsters phenomenon, gazes fondly at a procession of the animated creatures he has created. Acton's face (he's dropping the "Smith" this year, he says) is about the only non-cartoon image in the magazine, which overflows with the brightly coloured and zany inhabitants of the Moshi world. But it is also appropriate. Here is a man who is so engaged with his products that he loves them as much as his audience does. And his audience (he prefers the word to "customers") is impressive. Sixty million children in 150 countries log on to the Moshi Monsters website to play games and puzzles, socialise with each other, nag their parents for premium membership and buy the rapidly expanding line of licensed goods – toys, collectibles, trading cards, even a duvet set – that is turning Mind Candy from a very successful Shoreditch tech startup (valued last year at about £125 million) into what may be the first truly global company to have successfully bridged the gap between online and offline.

For those without age-appropriate children (the site is targeted at seven- to 12-year-olds), Moshi Monsters is a world of cuddly but odd-looking virtual creatures called Moshlings. Users adopt one, give it a name and set off to explore Ooh La Lane, Sludge Street, the Moshi Theme Park and other delights of the brightly coloured Moshi world. There they earn Rox to buy clothes for their pet and furnish its room, mostly by completing puzzles and challenges, and they can make friends with other users via their pets, building up a social network of other Moshi fans and visiting them in their own, invariably garishly outfitted, rooms. Much of the site is free, but there are paid-for members-only areas such as the Underground Disco and the Googenheim Gallery, where you can exhibit your own art. (Membership starts at £4.95 per month, rising to £30 per year.) Members can also access better challenges and have more friends.

Acton, 37, has always had an entrepreneurial flair. "I like ideas and doing fun stuff and seeing if it works," he says. Growing up in Marlow, he "did those annoying things kids do – selling apples to neighbours, carwashing, stuff like that". He set up a computer magazine at school, started a gambling ring with his friends, put on BMX stunt shows and dug a hole in the garden which he intended to fill with water for breeding koi carp. His parents were "very supportive, nurturing my silly ideas".

In 1998, after leaving Birmingham University, he and a friend, Tom Boardman, set up Firebox.com, an online toy-and-gadget retailer, with a £1,000 loan from Acton's mother. The company limped along ("We were making tens of pounds a month," says Acton), until the pair developed a shot-glass chess set. Each time a piece was taken the victor had to drink its contents, rapidly equalising the two players' ability. Aimed at far from serious chess players – rules included "Illegal moves are permitted as long as neither player notices" – the set cost £100. Firebox sold 25,000 in the first month. The pair moved to London and raised £500,000 from Spark Ventures, whom they had first met at a First Tuesday event.

Acton began to detach himself from Firebox, which still thrives, in 2004 (he still has shares and is a director) to focus on a new venture, Mind Candy, and its one product, an alternate-reality game, *Perplex City*. An online/offline treasure hunt involving collectible cards, physical challenges and events on the web, it set its users clues that would lead to a metal cube hidden somewhere in the UK and a £100,000 prize. At its peak, it gained about 100,000 followers, but too few people were buying the cards and revenue was poor. Acton had raised about £7m for the project, from investors that included John Hegarty, and Robin and Saul Klein's TAG group, but by mid 2007 the company was fast running out of funds.

"I was waking up at 4am and the worry part of my brain was going, 'What are you doing? This [*Perplex City*] is going nowhere,'" says Acton. "But I felt instead there was a big blue-ocean opportunity to create online entertainment for kids. I had seen how kids were using the web – and I saw how successful virtual pets had been, Tamagotchi and Furby. An important play pattern for children is nurture; plus children love collecting. So we created the hook of a virtual pet and just started from there."

Acton describes Moshi as "the last roll of the dice". *Perplex City* was put on hold (its site still promises "this is not the end") and Mind Candy's remaining cash (about

No. 1

UK's global ranking, out of 183, for ease of securing business credit

£700,000) was put into its cuter and more colourful successor. "Jumping ship and trying something completely different with the last bit of cash was the smartest thing to do," says Acton, "and it has turned out to be one of the smartest decisions I have ever made. I felt we had got caught up in our hype with *Perplex City* and it wasn't what the audience wanted. We had made something for a tiny niche."

Mind Candy launched a proto Moshi Monsters site on April 14, 2008 and then spent about 18 months refining what it had built. "Nothing much happened in that time. We tweaked and added new features until we got the features set that kids absolutely loved," says Acton. "Then it just took off. The penny-drop moment was when we realised that kids love to be social, and they love to be social just as much as grown ups do. If we could build a set of social tools that allowed them to chat and share in a safe way that parents would be comfortable with, we could build something as big as Facebook, for kids."

By the end of 2009, Moshi Monsters had eight million users. A year later that had grown to 35m, and at the end of 2011 it had reached 55m. Since late 2010, however, when it launched the first Moshi Monsters book, Mind Candy's revenues have been increasingly coming from the toys, games, collectible cards and other licensed goods made under the Moshi mark. Acton says he expects offline products to account for about half of Mind Candy's revenues "this year or next".

"Licensing wasn't intended to be part of the business but we wanted to let kids experience the characters more," he says. "I drew a circle on a napkin: Moshi.com is the middle and then around the outside magazines and books and trading cards, all interconnected. We feel the future of entertainment, especially in the kids' space, will have, as its starting point, an online experience – an online game, on mobile or in a virtual world like Moshi. Once that works and resonates and you have an audience of tens of millions, then you create the cartoon and the film and the books and the toys and the trading cards. Historically, with firms such as Disney, you start with a TV show or a film, that's the driver to a brand. But that doesn't work any more. Kids want to be part of a community and enjoy their entertainment in a much more interactive way. And that way, everything changes: it's much cheaper, you are moulding your product online, tweaking it, making sure the audience like it. And then, once it fits, you can invest in all the other peripheral stuff."

There's a glint in his eye when he talks about expansion (there's a copy of *The Disney Way* on his desk, though he doesn't rate the book). But Acton is well known for his caution. "He's very focused and doesn't go off track," says Tom Teichman, chairman of Spark Ventures, the early investor in both Firebox and Mind Candy. "He listens to advice and always has time to talk to backers. He has established himself as one of the most successful movers in the world in going from online to offline." Saul Klein says, "I call him Walt 2.0. He has the passion to build a Disney for the 21st century – and he has the ability to convert that into action."

13

Median number of days needed to register a UK business, according to the World Bank

HOW TO...

KEEP YOUR STARTUP ON TRACK

London-based Songkick, a huge social database of concerts, is growing fast and recently hired developers from Facebook and Google. Cofounder *Ian Hogarth* (*right*) offers a checklist to help other founders build effective launches

1. Find the people you believe you could build something amazing with. These are your cofounders.
2. Find something you love deeply that could be so much better. This is your market.
3. If you spent your lifetime on that thing, what could it become? This is your vision.
4. What is the smallest possible thing you could build that would test whether others agree? This is your minimal viable product.
5. Recruit the smallest team needed to build it. These are your seed investors and first hires. Be utterly ruthless about choosing people who share your values, vision and ambition level.
6. Build it and launch it. This is your first test.
7. Celebrate. It's really important to do this. That was some intense stuff!
8. Tell some people that you think will care. These are the most important people in the world now, the first ever users of your product.
9. Is there anything about your product that your new users couldn't live without? If not, return to step 4, it's OK. If so, onward!
10. Improve that specific thing that they can't live without. See if they start to tell their friends about how great it is.
11. Go back to step 3. Maybe it's even bigger than you thought. If so, tell everyone in your team how so.
12. Figure out a way to make money that is aligned with what your users can't live without.
13. Use that money to move faster towards your vision. This means making more users happier, faster.
14. Go back to step 3. Making something better is addictive. Doing it with the best people in the world, for something you love, is worth the heartache.

...PITCH ME!#2

BEN TOMPKINS, EDEN VENTURES

- **Get introduced by someone I know.** Social networks such as LinkedIn are great for this.
- **Come with your cofounder.** If you can show me you have found someone to share your dream (and take the pain that getting something off the ground entails), that is impressive.
- **Bring your minimum viable product (MVP).** With the software tools and services available today, it's possible to get your first product out there quite cheaply. It may not be pretty, but you should really have an MVP before approaching a VC.
- **Research me and my fund.** So that you understand my investment criteria (before meeting).
- **Ask for the order!** You are in sales mode now. Ask me for feedback, what are the next steps from my side etc. Push. The biggest evaluation I am trying to make in a first meeting is about you and the team. Don't give big market numbers without being able to back them up.

PHOTOGRAPHY: SPENCER LOWELL

HOW TO...

NETWORK EFFECTIVELY

Whether it's grabbing a burrito in Menlo Park or a pint at the Old Truman Brewery, meeting others in the startup scene is essential to grow your business. "The startup community is one of the most helpful, friendly and welcoming in the world," says Judith Clegg, who founded the Glasshouse networking group and now runs Takeout (*welcometotakeout.com*), a consulting firm. TC

THROW YOURSELF IN

Wired.co.uk/events has a constantly updating list to which anyone can contribute. Sites such as eventbrite.com and meetup.com are also useful for finding functions, many of which are free. Once there, abandon British reserve, advises Clegg: "It's OK to go up to somebody and say, 'Hi, I've come here to meet new people, my business is blah blah.'" Lost for words? Ask questions: entrepreneurs like talking about themselves.

BE SPECIFIC

Have a clear idea of who it is that you want to meet, whether it's investors, press or entrepreneurs. Do your research, so that you can spot people and have something to talk about ("I loved your guest post on wired.co.uk"). And be specific about yourself. "Be clear about your message," says Clegg, "so they remember the important thing about you."

GIVE AS GOOD AS YOU GET

"Build authentic relationships," advises Clegg. "Be a good citizen, not only looking for things yourself, but looking for ways you can support others in the community. Networking, I think, 'Can I help others?'" What goes around, comes around.

BE FIRM WITH TIMEWASTERS

If you get stuck with a conversational limpet, be polite but direct. Clegg suggests: "Say, 'I've really enjoyed talking to you,' pick out a specific part of the conversation, say, 'I'd like to take your card, but there's also a lot of people I've said I'd talk to, so if you'd excuse me, I'm going to catch them before I leave.'"

TAKE IT ONLINE

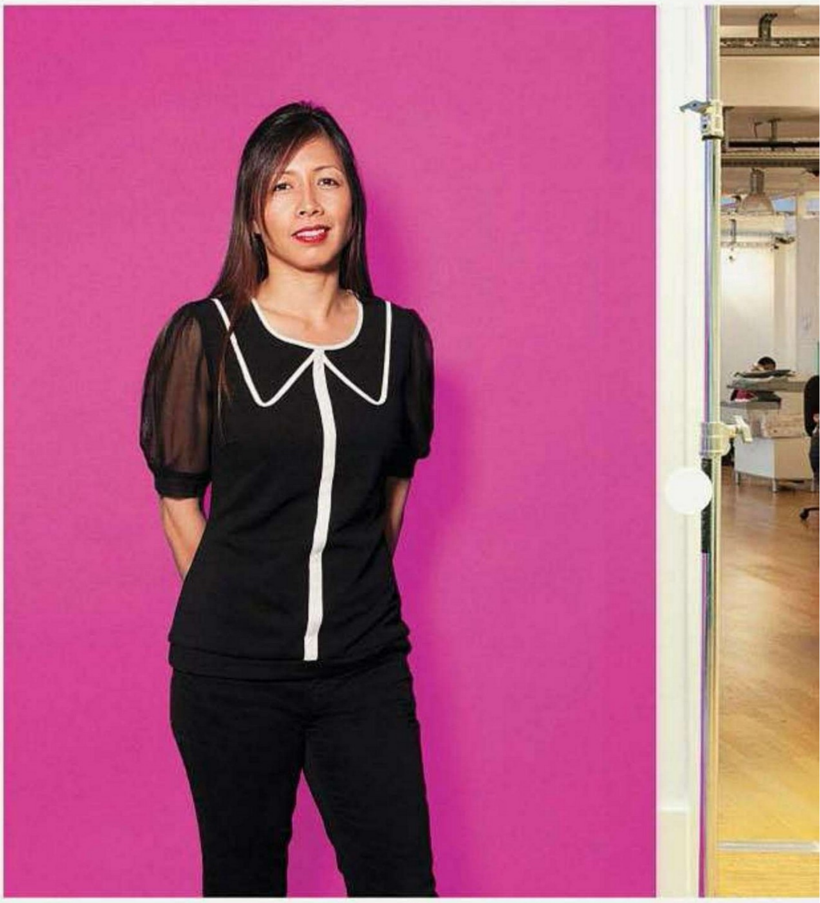
Clegg adds any business cards she receives to LinkedIn. Tech companies and investors use the site for recruitment (*see How To... raise angel investment*); keep your profile up to date. "It's OK to contact people you don't know on LinkedIn, as long as you're polite and clear about why you're connecting with them." A reference from a mutual friend is better.

HIT THE CONFERENCE CIRCUIT

"Conferences give you the chance to catch people three or four times over two days, if you've got on well," says Clegg. But don't corner speakers: give them your card and get out the way. Be wary of spending all your time at them: others may question if you're devoting enough time to running your business.

PIVOT IF NECESSARY

Changing tack when things went wrong was key to Wendy Tan White's success. By *Olivia Solon*



Klaus Nyengaard had witnessed the success of desktop applications for PCs and predicted that the same would happen with mobile phones. So in 2000, he created marketplace Mobli, secured funding and amassed the world's second-largest portfolio of mobile apps. Mobli predicted exactly how the 3G smartphone market would develop. Its mistake was expecting it to develop five years sooner than it did. "If you read reports in 2000, people were talking about 3G being just around the corner. We'd have smartphones in two years," explains Nyengaard, who is now CEO of Just-Eat.com. It was another five years before there was enough 3G coverage to make it a viable business, and eight years before the launch of Apple's App Store. "It's just as bad being too early as it is too late," he muses. Mobli's prematurity, combined with the founders' bullish resistance to accepting funding that gave them a runway longer than six months, meant that their coffers ran dry and they had to close.

Too much funding can be just as damaging as too little. Not only does funding have to be paid back, often at a multiple, but it also makes entrepreneurs lose focus, as Wendy Tan White (*right*) discovered with website builder Moonfruit. "We went from seed to a few million in funding within six months," she says. "That wasn't enough time to learn who our market was and what core features people were interested in. You end up spending money on the wrong stuff." White then shrank the company from 60 to two people: "In the dark years we learned to generate our own income and adopted what's now called the lean startup model."

The delicate funding balance is made more precarious by the fact that everyone at the table – the VCs, angel investors, the CEO with phantom stock – is keen to make money out of you. School for Startups founder Doug Richard took other people's advice and sold his company Visual Software for shares instead of cash, which lost 99 per cent of their value within weeks. "Everyone has a different set of incentives. Nobody has your interest, so stop whining and make your own decisions," he says.

One of the most terrifying decisions you need to make is to quit the day job. "If you don't commit full-time, you won't have the impetus to go and find

...PITCH ME! #3

ADAM VALKIN, ACCEL PARTNERS

Preparing a pitch is not just about raising capital. It's about hiring your first employees, closing your first sales and possibly even convincing your spouse it's a good idea. Here are five tips that may help...

- **Soundbites** Summarise the opportunity in a sentence, and repeat it. Tell us how to sell your project to our team. Great soundbites allow anyone who interacts with your company to become an ambassador.
- **Know the audience**. Research in advance who will be at a meeting. But most meetings do not turn into financing so get an intro to a client or an insight into the market.
- **Show stuff.** Traction speaks louder than words. If you're pre-revenue, show user growth and engagement. If pre-launch, show product and designs. If pre-product, show a great prototype. If pre-prototype, be very charming. Showing what you have built is an excellent way to convey your passion.
- **Do your homework.** Know your metrics and understand your industry. Demonstrate a focus on the unit economics of your business. Show real insight into the strengths and weaknesses of your competitors.
- **Engage.** Both you and the investor should leave the meeting wanting to work together.

customers or raise capital," says Adil Abrar, director of Sidekick Studios. He built gaming platform Budge, which fizzled out because he ran another company. "There was no real incentive to make it work because our mortgage didn't depend on it."

Assertive decision-making is also critical when it comes to firing a misfit, as Simon Campbell took too long to discover with his web-applications company Conexia. Aged 23, he was dazzled by an experienced former Oracle salesman who had charisma and impressive contacts. The startup agreed to pay him more than everyone else in the hope that he'd make sales. After a month without signing anything, it became clear that he wasn't right for the job, but Campbell kept the faith that he'd come through. He never did, and tried to sue the company when it did ask him to leave three months later. Conexia didn't fail, but the incident zapped morale and set the business back by 12 months.

"Work out what's right for the business and what it can afford," Campbell explains. "If sales people want a massive base, there have to be question marks about what they will deliver. If you realise you have made a mistake, get rid of them as soon as you can."

Just as important as people is the place you start your business, as Luke Johnson, chairman of Risk Capital Partners, discovered when trying to launch mussels-and-frites restaurant chain Belgo in New York. "We completely underestimated the cultural and economic differences between the UK and America," he explains. "The restaurant business in New York is much more competitive than in the UK and with much lower expected returns." Two years and $5 million (£3 million) later, Johnson and his partners retreated from the US.

Even with the right timing, people, place and product, you're not immune from failure, as Eric Ries (see interview on p111), author of *The Lean Startup*, discovered when he started Catalyst Recruiting out of his Yale dormitory. He explains: "We had a really beautiful business plan – with census data, market research, complicated models and strict customer-acquisition budgets. However, we just didn't know exactly who our customers were." Ries classifies his mistake as "achieving failure": being so focused on executing a plan that you don't ever pause to assess if it's good or not, thus wasting energy going in the wrong direction. The solution? To continually test the market and iterate.

Wendy Tan White is the founder and CEO of Moonfruit. moonfruit.com

PHOTOGRAPHY: SPENCER LOWELL

HOW TO...

SCALE INTO OTHER MARKETS

Focus abroad, not just to expand but to find a good mix of talent. By serial founder *Stephan Uhrenbacher*

There is no right or wrong advice that's true for all businesses. You either need to do a lot of work on the ground in sales or marketing, or you might just get away with having only a great central search-engine marketing team. Often the latter can have a bigger impact, if done right.

Most companies choose to have product central, and sales and marketing decentralised in other markets. This is tried and tested and works well if your product is "one size fits all". The danger of the traditional system of a strong HQ and relatively weak satellites is that if local tastes and preferences differ too much, you will never get it right. It's very rare to find satellite offices where people do not feel marginalised and unhappy. So how do you overcome this?

One interesting twist these days: if you are in an attractive location such as London or Berlin you can get the people from other countries into your HQ. We have done this for 9flats.com in Berlin. Currently, we have 14 different nationalities working at our office there. We have French, Italian and Spanish people who moved to Berlin to do local marketing in their home markets. Hence if something is not right for Italy, people will go up to the dev guys and tell them about it until they fix it.

Always hire key people from other countries. At Qype, a company headquartered in Hamburg, we had an English CTO and a French COO, and today we even have an English CEO for Qype. At 9flats, our CTO is Mexican and our head of sales is Russian. I like the culture this creates and it has worked well for us.

However, managing across cultures is not easy. There are many invisible caveats: people might say similar things but their different cultural context will associate totally different meanings. "Consider it done" means something totally different in different cultures. I was often surprised that our Spanish colleagues often had a more Germanic approach to work than the Germans. And it is more stressful than most people admit: you will find that people do get tired more quickly if they have to run meetings in English.

Stephan Uhrenbacher is the founder of Qype. qype.co.uk

400,555

Number of UK companies incorporated in the 2010-2011 financial year

HOW TO...

MAKE THE MOST OF LONDON

Tech clusters attract talent and investors – and that's why *Tamas Locher* moved his business here from Vienna

There is a consensus among European investors and entrepreneurs that London, Berlin and Stockholm are in the lead when it comes to enticing the next generation of web entrepreneurs. Recently, London has attracted companies such as Qriously, Brainient, UberVU and our company LOOKK to relocate their HQ. Most of these firms are small, generating only a couple of million in revenue or less, but some will become big businesses in the coming years, employing dozens, even hundreds of people.

There are many reasons for relocation but most of them we all share. For our industry, London is hugely relevant as one of the major fashion capitals. With great connections to Paris and New York, this makes it the epicentre. Qriously was driven by a similar reason for relocating in their particular industry. London attracts talent, the true drivers of early-stage companies, for cultural and quality-of-life reasons as well as for business opportunities. A healthy tech sector needs job mobility – and a liberal migration policy. London has that.

The vast majority of the European venture-capital industry is in London. Investors prefer to have early-stage companies especially close, but the investors are hardly likely to move to where their companies are. Naturally, it's the companies that need to move closer.

Once a critical number of entrepreneurs, investors and service suppliers operate within a given geographical area, an ecosystem is born. London has reached this critical mass. A striving ecosystem has the potential to incubate the next generation of multibillion-dollar companies. London is in a strong position to produce a bunch of these businesses in the next few years. This will then trigger the next phases – when enough entrepreneurs have the experience and money to plough back into the ecosystem. This will then trigger the next phase – when multiple entrepreneurs can plough back into the ecosystem. This is the first moment when a serious comparison with Silicon Valley will start to make sense.

Tamas Locher is cofounder and CEO of LOOKK

HOW TO...

CRACK THE VALLEY

London startups are expanding to San Francisco – but there are some basic rules. By *Andy McLoughlin*

PHOTOGRAPHY: SPENCER LOWELL

Silicon Valley. The land of startup milk and honey, home of deep-pocketed investors and the place where everyone is the CEO of something or other. In May 2010, shortly after closing a $10 million funding round, Huddle, an interactive cloud-based storage service, opened its first foreign office, in San Francisco. You can find plenty of advice elsewhere on visas, incorporation and the US healthcare system; here are some harder-to-find lessons that we've learnt along the way.

No surprises: hiring is hard and, in Silicon Valley's hyper-competitive echo chamber, retaining good people can be even harder. As well as the usual considerations (nice offices, free food, etc), there's also the question of minimum viable office size. People need to feel like they're in a thriving and important office, rather than a distant branch, miles from HQ. Fewer than four people in an office is simply too small – if one or two people are out for the day, someone will likely end up sitting on their own. Ideally, you need eight or nine people to ensure that the office has some buzz. Until you can commit to that number, consider either a coworking space or, better, take a decent-sized office and rent the spare desks to other startups. If things go to plan, you'll need the space eventually.

Also think hard about who will run your US office. Although I'd always advocate sending a founder (it's a tough job...), this may not always be possible. There is undoubtedly a huge amount of experienced talent in the San Francisco Bay area, but be wary of the Valley executives who've "been there and done it" for several large companies. Working for a scrappy British startup is hugely different from sitting inside a large corporate and a shiny résumé doesn't guarantee success. If you do find that dream person be very careful with muddy reporting lines – it's all too easy to make a great hire on the west coast and expect them to start leading a team five thousand miles away.

It's often said that familiarity breeds contempt but, in our experience, distance can breed confusion. Working across five thousand miles and an eight-hour time difference can be difficult and the dissemination of information that occurs naturally when everyone is in the same place stops happening. The best remedy is simple over-communication. Hold weekly company-wide video conferences, set times to speak with your team (with punishments for no-shows; there's little worse than a 7.30am catch-up with yourself because your colleague has forgotten to notify you of a clash) and rules on replying to queries from the other office (not responding asap means people could be waiting almost two days for an answer). Also, be prepared to start earlier and have your team work later; 7am meetings are a key (if un-fun) weapon in maximising the precious time when your offices overlap.

162,989

Number of UK companies liquidated in the 2010-2011 financial year

Distance doesn't have to be a killer – by following our own guidelines, my cofounder and I now communicate (and get on with each other) better than ever. Oh, and don't refer to San Francisco as "San Fran" or, worse, "Frisco". It tends to upset the locals.

Andy McLoughlin is cofounder of Huddle. huddle.com

HOW TO...
BE ACQUIRED

The exit isn't the end of a startup and it may not even be the beginning of the end. Roy Tuvey founded Scansafe with his brother in 1999; in 2009, Cisco acquired the British business for $183 million. Tuvey explains how to manage an acquisition. TC

SHOW A BIT OF LEG

"It's like finding love: you've got to get out there and socialise," says Tuvey, who moved to Silicon Valley. "You've got to show a bit of leg. It's impossible to do as an outsider." Tuvey says it took him 18 months to become a Valley insider, so plan ahead.

MAKE IT COMPETITIVE

Successful socialising means you'll be on the radar of several potential buyers. But be transparent with all sides: "You've got to run the process with a ton of integrity. Because if they think that you're playing both sides and being wriggly, then you might blow the whole thing up. Everyone talks."

FORGET ABOUT MONEY

If you've made it this far as an entrepreneur, making a quick buck probably already takes a back seat to building a great business. The same goes for the exit. "Unless someone's offering you double what the other is," says Tuvey, "you've got lots of other considerations – what's the best place for my staff, what's best for the legacy of my business."

KEEP RUNNING YOUR BUSINESS

"Keep selling as you're talking, keep out in the market," says Tuvey. "Keep winning customers – that's the best way of making buyers feel they have to do something." Operating your normal business and negotiating an exit are both full-time jobs, so be prepared to work hard.

MANAGE THE TRANSITION

"There's a lot of issues when you integrate – there are cultural differences as you start getting mixed into a much, much bigger organisation." Watch out for seller's remorse, says Tovey. Then what? Follow his example and launch a new company.

HOW TO...

BOOTSTRAP

Do you really need outside funding? James Eder, cofounder of The Beans Group, which includes studentbeans.com, explains: "When I created a business plan as part of my university degree, I never imagined that my original idea would grow to employ more than 25 people, especially as we started with no money. As we grew we needed to be dynamic, resourceful and efficient with the little we had. The good news: there are plenty of cheap or free tools that make all the difference. These are my favourites."

KEEP TRACK OF RELATIONSHIPS

Highrise (highrisehq.com) is a contact-management system that transformed our business. We work with some of the nation's most-loved brands, but it's the people behind the brands that we have relationships with. Highrise keeps track of people and conversations across the whole business.

MANAGE YOUR (SCANT) FINANCES

We use Kashflow (kashflow.com), an easy-to-understand online accounting system. It integrates with the tax system and produces fantastic accounting and management reports.

ENSURE YOUR INVOICES ARE PAID

When you start out, an unpaid invoice can be the difference between success or failure. For just £2 we use Thomas Higgins (thomashiggins.com), solicitors who issue a letter before action. Instead of chasing debts, we can focus our time and energy on growing and exploring opportunities.

USE FREE, CLOUD-BASED SOFTWARE

Why use expensive software? We use Dropbox (dropbox.com) and Google Docs (docs.google.com) and store all our work online. This approach can even remove the need for an office.

HOW TO...

HIRE ENGINEERS

The generally accepted rule is that "great" software developers are ten times more productive than merely "average" developers. With most startups failing, you need every edge you can get. Kieran O'Neill, founder of Playfire (playfire.com), offers three essential tips to hiring those greats, taken from the trenches of three successful tech startups.

1. The best developers have hundreds of options, so you need to make your company an attractive place for them to work. That means equity stakes, interesting technical challenges, creating a culture where developers are the rockstars, time to hack on personal projects and freedom to choose whichever languages or frameworks they want.
2. Try to open-source code you write which can be useful to other people as it raises awareness of your company among open-source developers, many of whom are the "great" engineers you're after.
3. You need to have a bigger vision. The best developers are attracted to startups with inspirational missions such as improving healthcare. Identify this mission and constantly reinforce it throughout your job advert and interview process.

HOW TO...

ADAPT ON THE FLY

When the market loves the part of your product that you consider unimportant, ditch the rest, says Alicia Navarro. By *David Baker*

In the startup world, sometimes a tiny detail of your product will turn out to be the one that makes you money. In September 2007, Alicia Navarro moved from Sydney to London to promote Skimit, a site that lets users bookmark products they find online, to compare before making a purchase. She'd developed the prototype in Australia but came to the UK, she says, because of its "more vibrant" startup culture. The site worked and she spun off a white-box version, but revenues were poor.

After a year of hard selling but few sales, she brought Joe Stepniewski, an old university friend, into the company. They monetised the links that took users back to the retail site to make a purchase. If the user bought, Skimit received a fee from the retailer.

Affiliate marketing was already common on the web – CDNow and Amazon were early advocates in the mid 90s – but it was limited to content generated by the site owner. Skimit was one of the first sites to monetise user-generated content on the fly, setting up a fresh affiliate link each time a user bookmarked a product. And when Navarro and Stepniewski went out to investors, it was that small piece of back-office tech that caught their eye.

"People weren't interested in our sexy front-end social-decision-making tool, but in this kind of back-end monetisation technology," says Navarro, 35. "So we made the decision to give up everything that I had built for the last two years and focus on commercialising this technology – something we had built just for ourselves."

The result was Skimlinks, a service business that automatically adds affiliate links to live web pages and an almost textbook example of a successful pivot. Users type a link to a product in their blog, for example, and Skimlinks converts it instantly into a link that will make them money. Mention a product by name and the technology will create a pop-up box, showing where it can be bought online and for how much.

Shaped in this new way, almost immediately the company found clients and investors. Shiny Media, a web publisher, and AVForums, which runs bulletin boards for audiovisual enthusiasts, incorporated white-box versions of the technology into their sites. And two weeks later, at the end of November 2008, Skimlinks had its first VC capital: £500,000 from Sussex Place

...PITCH ME! #4

DAVOR HEBEL, FIDELITY GROWTH PARTNERS EUROPE

- **Be complete.** Cover all the key points succinctly including the story behind the idea, vision, market, competition, financial plan and routes to exit. Bring your key team members and show off all the hard work.
- **Manage time.** If you can't stay punctual in the pitch, will you in real life? There is always an opportunity for a follow-up meeting.
- **Know the competition.** All viable ideas and markets have direct and indirect competition. Know who they are and what they are up to. Meet them and develop a working relationship. "Keep your friends close..."
- **Have a working and memorable demo.** A picture is worth a thousand words and a cool demo probably a whole novel. No matter what the idea, bringing it to life will add a whole new dimension.
- **Help me make money.** Yes, I love entrepreneurs, but I have to make money for my investors. Think about your business from that perspective and you will be well on the way to funding.

AND ONE THING I HATE: Evading my questions.

Ventures. The company now has 20,000 clients in 20 countries and in December last year, says Navarro, posted a profit. (She won't comment on financial details.)

The decision to pivot was hard. "It's easy to jump ship and change direction if you haven't invested that much," she says. "But I'd invested two years, a lot of my personal reputation and most of my personal savings."

"You never know the best time to make the move," says Stepniewski, 32. "If you are completely data-driven and your data says it's not going to work, you should pivot away. But who knows? Maybe that idea would have had legs if you had stuck with it."

Skimlinks has benefitted from Navarro's and Stepniewski's contrasting characters. Navarro is a tireless promoter of her company. (Robin Klein of The Accelerator Group, an early investor, calls her "an exceptional entrepreneur, all action".) Stepniewski is the more analytical of the pair.

Percentage of UK population aged 18-64 running and/or owning a new business

"Joe and I have arguments...," says Navarro.

"Debates..."

"...about data versus instinct. Personally, I think really good entrepreneurs can feel [when to pivot] because they know their customers so well. I was out there on the street, talking to customers every single day and I saw what brought the twinkle to their eye, I saw what they were bored by. You understand your customers' challenges and that's where inspiration comes."

She loves London as a base, but is now based in San Francisco building the US side of the business. She also has a reputation for not taking no for an answer. "My favourite saying," she says, "is: 'Everything is possible, you just haven't worked out what the answer is yet.'

"The CEO has to be the biggest believer, because everyone in the company is looking for inspiration from them," she says. "But they also have to be the first person to be brave enough to make a change if necessary. I have seen a lot of friends' companies that should have pivoted ages ago. And you should never lose sight of who you are and who your friends are, because this business has the potential to swallow your entire life and swallow your identity. You don't want, five years after you exit, to have a lot of money but no friends or family."

Alicia Navarro is the founder and CEO of Skimlinks

PHOTOGRAPHY: SPENCER LOWELL

HOW TO...

CASH IN ON A TREND

As an investor you need to look out for the startups best placed to monetise the macro trends unnoticed by other companies. By *Niklas Zennström*

Entrepreneurship is about creating successful businesses, not just finding or inventing a new technology or service. People often ask about this, and how Atomico, my venture-capital firm, identifies and chooses great companies to invest in. Our thinking often involves macro trends – the major trends in technology, and how they create big opportunities.

Take Rovio, the Finnish company behind the *Angry Birds* games. It's reached more than 600 million downloads worldwide, and is probably our best-known investment. Much of *Angry Birds*' brilliance is about great gameplay and characters that sell more than a million fluffy toys a month.

But it's worth considering some of the macro trends at work. The first is mobile internet and the popularity of the App Store. Rovio had been making mobile games for years before *Angry Birds*, but before the popularity of mobile downloads. This meant that games were pre-installed by phone makers. The App Store changed this, allowing consumers to download games directly from the game company itself, and making the potential profits much greater.

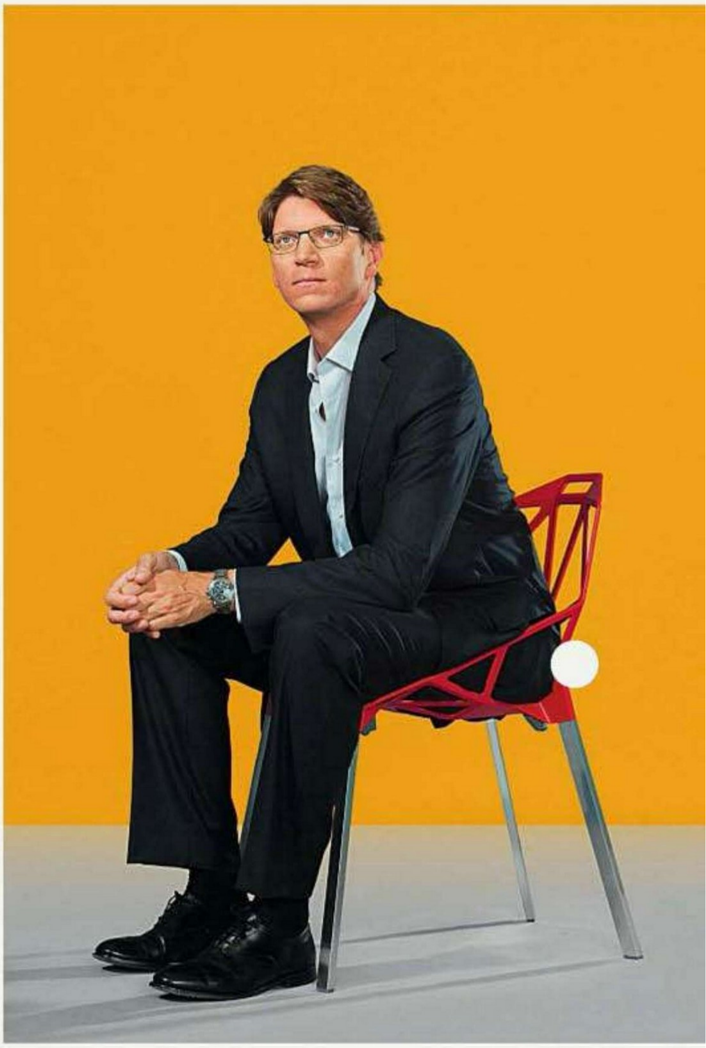
A second, big, related trend was smartphones. They had far better graphics and sound, meaning far better, more popular games.

And a third big trend was touchscreens. *Angry Birds* was specifically designed for them, and it's part of the game's huge success.

What impressed us so much about Rovio? Not that they had benefited from these trends, but that they had specifically designed the game, and a global entertainment franchise, to do so. Think about that if you want to succeed as a tech entrepreneur, or next time you fire a bird into the sky.

Niklas Zennström is a founding partner of Atomico, the international venture-capital firm, and also a cofounder of Skype and Kazaa

Percentage of UK population that knows someone who's started a business since 2008



HOW TO...
HIRE TALENT

1. Exploit your network for potential employees or referrals before considering using a recruiter. Great businesses are built on great referrals.

2. Think about and create an attractive company culture. Understanding and building a robust cultural DNA for your startup will help you hire and retain the best candidates.

3. When making a hire, ask yourself: "Would I enjoy sitting next to him/her on a long-haul flight?"

4. Try to hire executives with past startup success. They will understand the requirements of a rapidly growing company. They will also help you avoid the mistakes they made or experienced.

5. Do not hire executives who don't fully understand the demands of a startup.

6. Locate your business as close to the talent pool as possible. If this is not possible, be prepared to entice the right candidates to you, or relocate.

7. Hire slow, fire fast. The right employee can help you grow rapidly, even exponentially, but the wrong employee can set you back 12 months. Work out why they weren't suitable before you make your next hire.

By Brett Putter, managing partner at the Forsyth Group

HOW TO...

EMBRACE FAILURE

The startup community's unofficial but widely consulted biographer, *Eric Ries*, speaks from experience of both falling flat and succeeding

Most businesses fail. Eric Ries, founder of two startups (the first tanked; the second rocketed), thinks this is a good thing. "We think failure is an inevitable part of the discovery process," says Ries. "Just as in science you go down blind alleys. No one is born with that knowledge." The author of *The Lean Startup* (theleanstartup.com) explains how to build failure into your business with constant adaptation. TC

DON'T BELIEVE YOUR OWN PLANS

"Pretending that your plans predict the future – that is the root error," says Ries. Being ahead of your plan doesn't mean you're doing a good job if it turns out to be the wrong plan. Instead, build a minimum viable product – the bare-bones technology or service – then get it to market and start tweaking.

USE CUSTOMER FEEDBACK

"In parallel with product development, you want to have a process for discovering who the customer is you're building for," says Ries. This means meeting them and finding out what they want by putting the product in their hands. "If your engineers don't understand your company's positioning, they won't build a product that early adopters want."

KEEP THE BATCH SIZE LOW

Batch size refers to how much work passes from stage to stage of development. "Imagine that you're mailing out a bunch of physical newsletters," says Ries. "You have 100 letters and each has to be folded, stamped, addressed and stuck in a mailbox. The intuitive way to do that is fold all 100 letters, then stuff all those letters etc. But it's a matter of fact that the counterintuitive way is faster – that is, if you did them one at a time." Large batches means more time wasted on managing inventory – collecting and moving envelopes. It also means problems become more painful. "If there is a significant problem with the plan – imagine that the envelopes don't fit the letters – when would you want to find that out? After you've folded all 100 of them or after you've folded one?"

KEEP THE LOOP CONTINUOUS

"I don't subscribe to the steps or stages theory of startups," says Ries. It's a loop: "build, measure, learn." At the end of the loop is the pivot, where you change your business, slightly or dramatically: Fab.com turned from being a moderately successful social network for gay men into a booming daily-deals site for interior design.

HOW TO...

MANAGE A FAST-GROWING TEAM

As CEO, you're nothing without your team. They are your most valuable asset and your only tool for execution. The Videoplaza team assembled by Sorosh Tavakoli has grown from three to 50 in four years. So how do you scale your team?

ENSURE THE TEAM CAN ADAPT

Everyone in your team must expect to step up on a constant basis. Your company's needs will change, so in a fast-growth business, the role they were hired to do in the first place will have changed – so you need to make sure they can grow with it. Delegation is always a difficult thing when you're the founder, but true ownership is the only way to get people to step up.

DON'T BE AFRAID OF FIRING

Not everyone will be able to keep up with the pace. Here comes one of the toughest parts of the job. You need to constantly re-evaluate not only your team members, but also your own fit with your role's requirements. Be honest. Dare to ask the right questions and make the tough decisions. Half our management team were hired during the last 12 months.

ANTICIPATE YOUR NEEDS AND YOUR TEAM'S REWARDS

Recruiting the right people means understanding your needs 12 to 18 months ahead. In sourcing that talent, you need more than charm: you need a super-strong vision of where the company is going. You may need to give away equity if you can't afford the quality of people you really need.

Sorosh Tavakoli is founder and CEO of videoplaza.com

PHOTOGRAPHY: DIVER AGUILAR

HOW TO...

RISK IT, AND RISK IT AGAIN

Gil Penchina, CEO of Wikia inc., investor in PayPal and former VP of international at eBay, aimed to launch eight startups in 2011. So how did he do?

I've been lucky enough to be involved in a number of great startups, including eBay and Wikia as an entrepreneur and LinkedIn and Paypal as an investor. After watching them all grow, I decided I enjoyed the very earliest phase of a startup. So at the beginning of 2010 I set a goal of launching eight companies in 2011. Crazy? Sure, but great athletes set impossible goals and achieve so much by getting halfway. And I love early-stage startups

Along the way I learned the key to launching a company. It's all about storytelling. I would come up with an idea, or hear an idea from a friend who thought "someone needs to do that". I'd take the idea, tweak it and then tell everyone that it was the best idea ever and that I wanted to start a company around it. I'd do it at cocktail parties, at conferences, while watching sport. I just wouldn't shut up.

After doing it with a variety of ideas it quickly became apparent which were bad. Bad ones got me feedback like "meh", "been done three times before, don't you know about X".

Good ideas got me criticism. Lots of it: comments such as "Why are you making it so hard? I would start with a much easier product" and "Dumb – where's the revenue going to come from?" When trying to start a company, your enemy isn't criticism, anger or insults. Your enemy is apathy. When no one cares, they don't even bother telling me I'm stupid, they just walk away.

As I homed in on an idea, I could see heads start to nod. Typically the people who "got it" first were industry insiders. As the idea improved, I would start seeking out the catalysts required to start a company: a cofounder and an investor. I started mailing lists of everyone who cared enough to criticise. I found enthusiasm faded if there wasn't something on the email list at least every 48 hours, so I would keep moving the idea forward and reply to people who posted comments. As I brought more people in, it started to feel like a project. Then someone would take the initiative and do something without prompting. I'd smother them with praise, and the next thing I knew they were doing research or taking ownership of a project. My job was to be the cheerleader, to keep the drumbeat of progress going and occasionally to be the nag (project manager).

At my best companies, a cofounder emerges from this process and takes complete ownership of the company. In 2011, I failed to achieve my full goal, but I am still amazed by how much fun I had. Only two of the five companies I cofounded are public, the rest are still in stealth mode:

- Fastly: a real-time content network, competes with Akamai
- GetAShare: paying people for their attention online
- A data business that collects and monetises high-value changes in consumers' lives
- A mobile marketplace for local services, funded but still in development
- A financial-services firm.

If I had more time, I'd explain how getting a startup off the ground once you have a team in place is like pushing jelly...

Gil Penchina has made angel investments in companies such as LinkedIn, PayPal, Zip Realty and Couchsurfing

...PITCH ME! #5

DANIEL WATERHOUSE, WELLINGTON PARTNERS

Get to the point quickly in a pitch. Show your passion for what you do. Don't spend the first 20 minutes explaining the market. Explain the product and tell us why what you are building is important and why it will exist far into the future.

- Tell us about *you* and your cofounders. The three most important things we look for in a business are people, people and, er, people. Some teams we see leave the presentation of the team to the last slide – big mistake.
- Try to distil the essence of what you are doing into a short summary, thereby tackling the problem of VC attention deficiency, while helping the investor to later capture the attention of their partners. The next stage for us is to pitch the company on your behalf, so make it easy.
- Oh, and please don't send us a 100-page business plan – the chances are that no one will ever read it.

68

Percentage of VCs who plan to invest in clean technology in the next five years in the UK

ONLINE 'HOW TO' EXTRA

Visit the WIRED website for more How To advice from contributors including BraveNewTalent, RadiumOne, Ballou PR, Microsoft BizSpark and more – plus events and conferences recommended by founders themselves: wired.co.uk/howtostartup

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BY
JONAH
LEHRER

THE NEW RULES OF CREATIVITY

HOW CAN YOU BOOST YOUR BRAIN'S CREATIVE STREAK IN THE WORKPLACE? TRY THESE MIND HACKS SPECIFICALLY DESIGNED TO GIVE YOUR GREY MATTER A SPRING CLEAN

According to a recent survey of 1,500 chief executives from all over the world, the most important skill they seek in employees is creativity. New ideas, after all, are the ultimate source of economic growth. But this only raises the question: how can we generate *more* creativity? How can we inspire people to have more new ideas? If we designed a workplace that was all about maximising innovation, then what would that workplace look like? What follows is a short list of scientifically tested ideas that can boost the imagination, transforming the typical office into a wellspring of creativity.

STILL LIFE:
BARTHOLOMEW
COOKE

INSIGHT
CAN BE INCREASED BY
EXPOSING SUBJECTS
TO AN INCANDESCENT
LIGHT BULB

PAINT THE WALLS BLUE/

A few years ago, a team of psychologists at the University of British Columbia looked at the influence of different colours on how people think. They recruited 600 subjects, most of them undergraduates, and asked them to perform a variety of basic cognitive tests displayed against red, blue or neutral-coloured backgrounds. The differences were striking. When taking tests against red backgrounds, they were much better at skills that required accuracy and attention to detail, such as catching spelling mistakes. According to the scientists, this is because people automatically associate red with danger, which makes them more alert and aware.

The colour blue, however, carried a completely different set of psychological benefits. Although people in this group performed worse on short-term memory tasks, they did far better on those that required using their imagination, such as coming up with creative uses for a brick or designing a children's toy out of simple geometric shapes. In fact, subjects in the blue condition generated twice as many "creative outputs" as subjects in the red condition. The scientists explain this strange result by pointing out that blue triggers associations with the sky and ocean. People think about expansive horizons and diffuse light, sandy beaches and lazy summer days. We are instantly relaxed. As a result, it's easier to focus on those possibilities simmering in our imagination. Next time you need a new idea, seek out a loft-like space with high ceilings and lots of windows. Or just paint your walls blue.

TAKE MORE BREAKS/

The inconsistency of genius is a consistent theme of creativity: those blessed with talent still produce works of occasional mediocrity. This is because creativity isn't just about new ideas – it's also about evaluating those ideas and sifting through the clutter to find what's actually worthwhile. A study led by Simone Ritter, a PhD student at Radboud University, Nijmegen, helps to explain how we can get better at such evaluations.

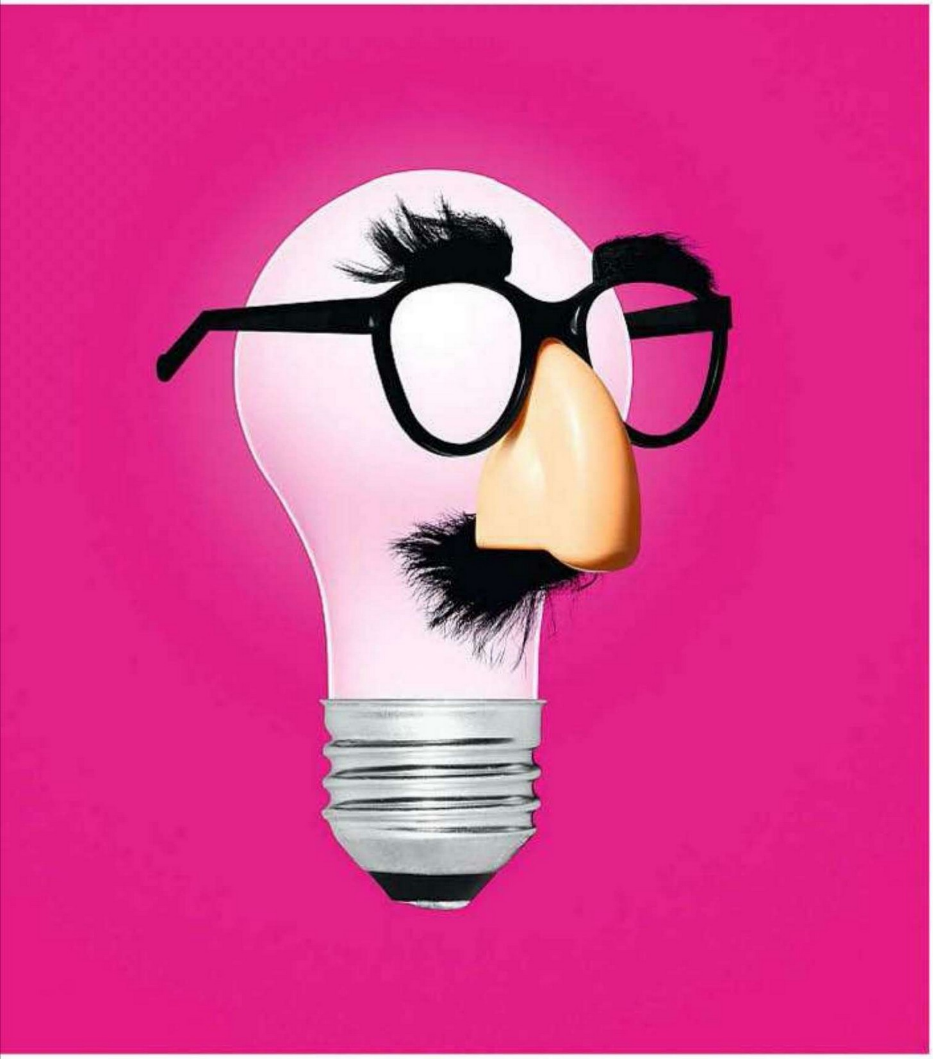
In Ritter's first experiment, 112 students were given two minutes to come up with creative ideas that might alleviate a mundane problem: improving the experience of queueing at a supermarket checkout. The subjects were divided into two groups. One went straight to work; the other was instructed to perform an unrelated task for two minutes first. (They played a video game.) After writing down as many ideas as they could, both groups were asked to choose which of their ideas were the most creative. Although there was no difference in idea generation, giving the unconscious a short break proved to be a big advantage. Those who had been distracted proved better at identifying the best ideas. Whereas those in the conscious condition only picked their most innovative concepts about 20 per cent of the time – they confused their genius with their mediocrity – those who had been distracted pinpointed the best ideas about 55 per cent of the time. In other words, they were more than twice as good at figuring out which concepts deserved more attention.

DREAM

KEITH RICHARDS CAME UP WITH '(I CAN'T GET NO) SATISFACTION' WHILE FAST ASLEEP

THINK LIKE A CHILD/

Picasso declared: "Every child is an artist. The problem is how to remain an artist once we grow up." But a study by psychologists Darya Zabelina and Michael Robinson at North Dakota State University suggests that it's possible to regain the creativity we've lost to maturity. A few hundred subjects were assigned to two different groups. The first was given the following instructions: "You are seven years old, and school is cancelled. You have the entire day to yourself. What would you do? Where would you go? Who would you see?" The second group was given the same instructions, except the first sentence was deleted. After writing for ten minutes, the subjects were then given tests of creativity, such as inventing new uses for a car tyre or a brick. The students who imagined themselves as children scored far higher on the creative tasks, with nearly twice as many ideas as the other group. Picasso would be proud.



WATCH MORE COMEDY/

Research led by Mark Beeman from Northwestern University, Illinois, and John Kounios from Drexel University, Philadelphia, suggests that happy people are more creative. Subjects scoring high on a standard measure of happiness solved about 25 per cent more creative puzzles than those feeling angry or upset. Even fleeting feelings of delight can lead to dramatic increases in creative success: after showing people a humorous video – the scientists use a short clip of Robin Williams's stand-up comedy – subjects solve about 20 per cent more puzzles, at least when compared to those who are shown scary or boring videos.

HAPPY

BEING IN A POSITIVE MOOD LETS THE BRAIN ENTER AN OPEN AND PLAYFUL STATE

HOW FLASHES OF INSPIRATION WORK

1.

Epiphanies seem to come out of nowhere, but your brain would have been laying the foundations for a while. When given a tough problem, its nerve cells start firing in the left hemisphere, which logically sifts through all possibilities and combinations. When it's looked in all the obvious places to no avail, you experience mental deadlock. This is a signal to the brain that a new search process is required.

2.

Brain activity now shifts to the right hemisphere. According to neuroscientist Mark Beeman, this side is responsible for seeing the big picture. Now you can grasp subtle connotations – the punchline of a joke or the meaning of a metaphor. The switch allows you to explore unexpected associations and perspectives.

3.

Thirty seconds before your "aha" moment, there is a sudden burst of brain activity called a "gamma-wave rhythm" which, says Beeman, is the highest electrical frequency generated by the brain. It comes from neurons forming new connections. The spurt of activity comes from the anterior superior temporal gyrus, located on the right hemisphere, just above the ear.

4.

Although lack of experience can be a drawback, it comes with the advantage of fresh perspective, increasing your chances of an epiphany. Dean Simonton, a psychologist at UC Davis, showed that physicists and poets make their greatest creations early in their careers. If you can leave behind your knowledge and constantly experiment with new, strange problems, you may just be inspired.

5.

Giving your brain some downtime makes inspiration more forthcoming – in the form of alpha waves radiating from the right hemisphere. They are emitted during relaxing activities such as taking a warm shower. Studies have shown that until these waves are produced, the brain will be unable to solve insight puzzles.

EMBRACE YOUR CONSTRAINTS/

The writer GK Chesterton once declared: “Art consists of limitation. The most beautiful part of every picture is the frame.” He was referring to the importance of constraints in the creative process. Although we tend to think of the imagination as benefiting from total freedom, artists and designers often rely on strict conventions and formal requirements. Pop songs have verses, choruses and refrains; symphonies have four movements; poets rely on forms with exacting specifications, such as haikus and sonnets. Why? A new study led by Janina Marguc at the University of Amsterdam provides an interesting and unexpected answer: the frustrations of form come with a mental benefit – letting people think in a more holistic and creative fashion.

The researchers began by asking subjects to work on anagram puzzles while a distracting voice played the role of obstacle. They then gave the subjects sensory tests to measure their ability to reason without becoming enmeshed in detail – in terms of the old adage, being able to see the forest and the trees. Those exposed first to the obstacle showed increased “perceptual scope”; those who hadn’t dealt with the hindrance lagged behind. When searching for creative solutions, we often find the answer in the forest. The trees hold us back. Such holistic thinking is often necessary when coming up with new ideas, which requires crossing the familiar boundaries of thought. This helps explain why those students first exposed to the obstacle solved 40 per cent more puzzles.

The larger lesson is that the brain is a neural tangle of near-infinite possibility, which means that it spends a lot of time and energy choosing what *not* to notice. Creativity is traded away for efficiency; we think in literal prose, not symbolist poetry.

It’s not until we encounter a challenge we can’t easily solve that the chains of cognition are loosened, giving us access to the weird connections simmering in the imagination. The benefit of obstacles also carries over into unrelated tasks, which is why starting the day with a difficult crossword puzzle or writing a haiku can help people to become better real-world problem solvers.

DON'T BRAINSTORM/

Brainstorming is the most popular creativity technique. It’s used in advertising offices and design firms, the classroom and the boardroom. Whenever people want to extract the best ideas from a group, they still obey the simple rules of brainstorming. The very first rule is well known: don’t criticise. After all, if people are scared of saying the wrong thing, they’ll end up saying nothing at all.

But this turns out to be a terrible approach. Keith Sawyer, a psychologist at Washington University, summarises the science: “Decades of research have consistently shown that brainstorming groups think of far fewer ideas than the same number of people who work alone and later pool their ideas.”

The flaw, it turns out, is rooted in rule number one of brainstorming, which bans criticism. Consider this study led by Charlan Nemeth, a psychologist at UC Berkeley. She divided 265 female undergraduates into five-person teams. Every team was given the same problem: how to reduce traffic congestion in the San Francisco Bay Area. The teams had 20 minutes to invent as many solutions as possible. At this point, each of the teams was randomly assigned to one of three different conditions. In the “minimal” condition, the teams received no further instructions; they were free to work together however they wanted. In the “brainstorming” condition, the teams got the standard brainstorming guidelines, which emphasised the importance of refraining from criticism. Finally, there was the “debate” condition, in which the teams were given the following instructions: “Most research and advice suggests that the best way to come up with good solutions is to come up with many solutions. Freewheeling is welcome; don’t be afraid to say anything that comes to mind. However, in addition, most studies suggest that you should debate and even criticise each other’s ideas.”

DEBATE

PIXAR ANIMATORS RUTHLESSLY DEBATE THE PREVIOUS DAY’S WORK EVERY MORNING

The results weren’t even close. Whereas the brainstorming groups slightly outperformed the groups given no instructions, people in the “debate” condition were far more creative, generating on average nearly 25 per cent more ideas. But that’s not all: after the groups had been disbanded, each of the subjects was asked if they had any more ideas, triggered by the earlier conversation. Whereas people in the minimal and brainstorming conditions produced, on average, two ideas, those in the debate condition produced more than seven. It turns out we’re tougher than we thought. The imagination is not meek – it doesn’t wilt in the face of conflict. Instead, it is drawn out, pulled from its usual hiding place.

WORK WITH STRANGERS/

2.6
LEVEL OF *Q* REQUIRED TO INCREASE THE CHANCE OF SUCCESS ON BROADWAY

Many of our hardest problems require collaboration, as they exceed the capabilities of the individual imagination. We either work together or fail alone. But what's the ideal strategy for group creativity? Brian Uzzi, a sociologist at Northwestern University, Illinois, spent years trying to answer these questions – and he's done it by studying Broadway musicals. Why? Because he sees this art form as a model of collaboration. Just think of all the diverse artists who need to work together: the composer has to write songs with a lyricist; the choreographer has to work alongside the director; the director has to deal with the producer, and so on.

Uzzi undertook an epic study of nearly every musical produced on Broadway between 1945 and 1989, analysing the teams behind 474 different productions. The first thing he discovered was that the people who worked on Broadway were part of an interconnected social network; it didn't take many links to get from the librettist of *Guys and Dolls* to the choreographer of *Cats*. Uzzi then came up with a way to measure the density of these connections, a figure he called *Q*. In essence, the amount of *Q* reflects the "social intimacy" of people working on the show, with higher levels signalling a greater degree of closeness. For instance, if a musical was being developed by a team that had worked together several times before, it would have a high *Q*. A musical created by a team of strangers would have a low *Q*.

This metric allowed Uzzi to explore the correlation between levels of *Q* and the success of the musical. According to the data, the relationships between collaborators was one of the most important variables on Broadway. When the *Q* was low, or less than 1.7, the musicals were more likely to fail: the artists didn't know each other and they struggled to exchange ideas. But when the *Q* was too high (above 3.2), the work also suffered. The artists were so close that they all thought in similar ways, which crushed innovation.

Uzzi's data led him to argue that creative collaborations have a sweet spot. "The best Broadway teams were those with a mix of relationships," Uzzi says. "These teams had some old friends, but they also had newbies. This mixture meant that they could interact efficiently, but they also managed to incorporate new ideas. They were comfortable with each other, but not too comfortable."

Uzzi's favourite example of "intermediate *Q*" is *West Side Story*. Several of its collaborators were Broadway legends who had worked together before, but, as Uzzi points out, it also benefited from new talent – a then-unknown lyricist called Stephen Sondheim.

"People have a tendency to want to only work with their friends," says Uzzi. "It feels so much more comfortable, but that's exactly the wrong thing to do. If you really want to make something great, then you're going to need to seek out some new people, too." Aim for the sweet spot of *Q*.

Jonah Lehrer will be in conversation with WIRED*'s Greg Williams at the Hospital Club in London on April 26. To win tickets see wired.co.uk. His new book,* Imagine *(Canongate), is out on April 19*

PREPARE TO IMPROVISE

1. LET GO

Being a good improvisational artist – whether you're a musician, a comedian or an actor – is all about losing your inhibitions. Experiments examining the brains of jazz musicians show exactly that: a specific brain circuit called the dorsolateral prefrontal cortex (DLPFC), which is responsible for impulse control, was deactivated while the musicians were in improvisation mode. So a performer whose brain has learnt to shut the DLPFC up is a great improviser.

2. LEARN THE LANGUAGE

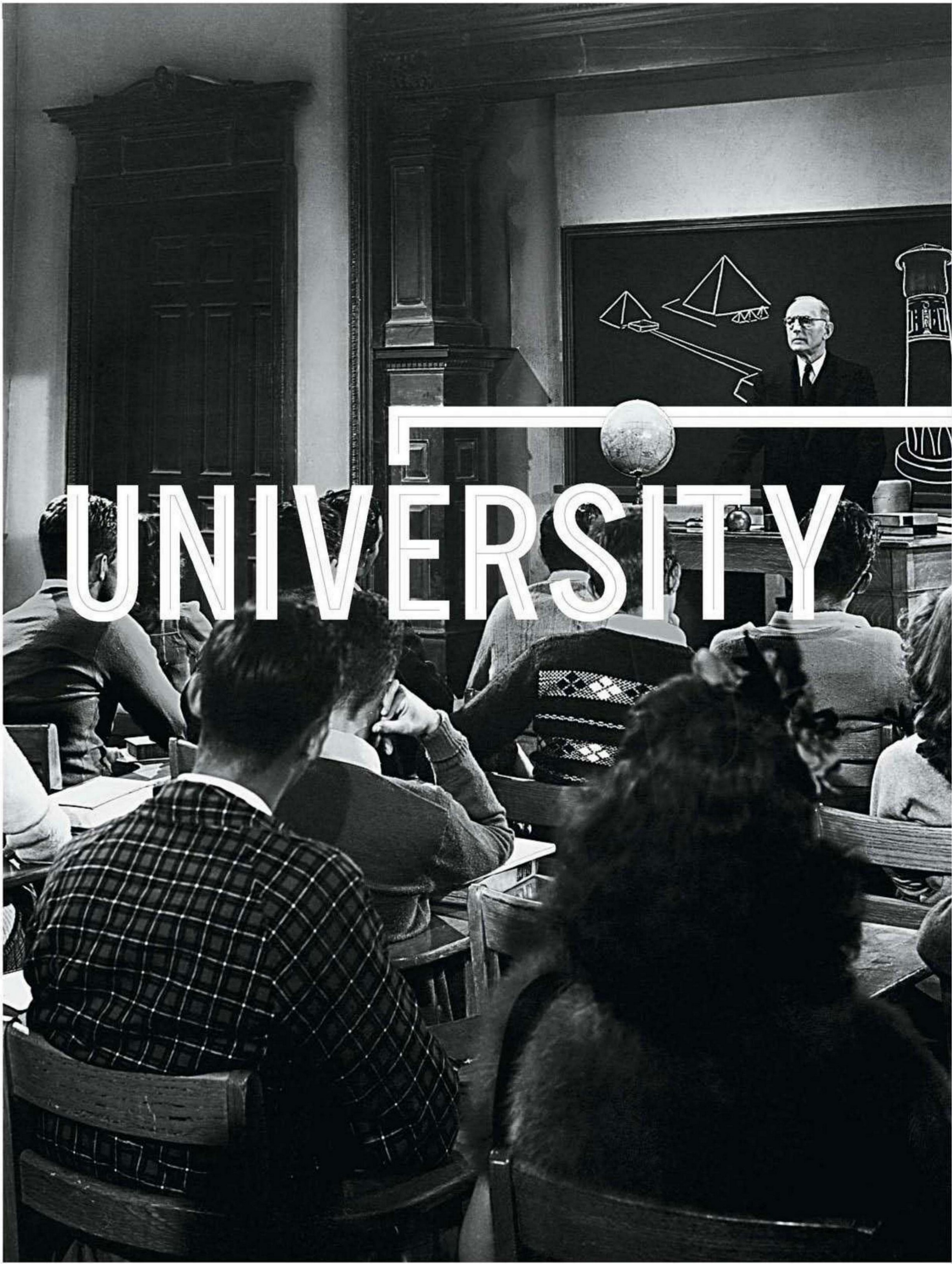
It's not enough just to forgo your better judgment. You need to have the vocabulary of your craft down pat before you can start to experiment. Harvard neuroscientist Aaron Berkowitz says of improv musicians: "There's no time to think of each individual note. They have to have some patterns in their toolbox." Once neural networks for the skill are firmly formed, they can break and reform with ease.

3. NEVER QUESTION

Improvisational comedians are taught a technique called "Yes, and...". The point is to learn to improvise in an ensemble. The technique forces comedians to agree with the previous joke, no matter what they think of it. They then build upon it by setting up the next joke immediately. That way, the jokes are layered upon each other and the sketch is a product of the entire group's creativity.

4. PRETEND IT'S A DREAM

According to cellist Yo-Yo Ma, the ideal state for performance is to feel like you're coming out of a dream. "Your unconscious is fully available to you, but you're still a little conscious too," he says. It's the same for comedy: you've got to be acutely aware of what's happening around you, but you've still got to learn to "leave your mind", according to improvisation instructor Andy Cobb.



UNIVERSITY

JUST FLIPPED

THE OLD MODEL OF LEARNING HAD STUDENTS PASSIVELY SIT IN LECTURES. BUT A NEW MODEL USES ONLINE VIDEO TO OPEN UP KNOWLEDGE TO THE WORLD – AND IN WAYS THAT EMPOWER THE LEARNERS

BY
**STEVEN LECKART
AND TOM CHESHIRE**
PHOTOGRAPHY:
CHARLIE SURBEY

AT STANFORD UNIVERSITY LAST SUMMER, COMPUTER-SCIENCE PROFESSOR SEBASTIAN THRUN SUGGESTED HE AND HIS COLLEAGUE PETER NORVIG DO SOMETHING NO UNIVERSITY HAD done before. The previous year, the pair had elected to take over teaching course number CS221: Introduction to Artificial Intelligence. "We felt it was time for a change in education," says Norvig. "No one had put together all the pieces in the same way we wanted to offer."

This year's course would be different: anyone with web access could take it. Lectures and assignments – the same ones administered in the on-campus class – would be posted and auto-graded online each week. Midterms and finals would have strict deadlines. Stanford wouldn't issue course credit to the non-registered students, but at the end of term students who completed a course would be awarded an official statement. In 2010, Norvig and Thrun taught their course to nearly 200 students, all from Stanford; in 2011, 160,000 students from 190 countries enrolled.

"I was flabbergasted," says Thrun. "I was blown away. I was also a little fearful, since it was clear we'd go to a place where I'd never been before. Before we went online, Peter had guessed 1,000 [students might sign up], and I had optimistically thrown out 10,000 without actually believing it. I usually try to guess high."

The university model, where academics lecture to student-filled halls, is broken. "This approach to education," wrote Eric Mazur, a physicist and Harvard lecturer, in *Science* in January 2009, "has not changed since before the Renaissance and the birth of scientific enquiry... The traditional approach to teaching reduces education to a transfer of information. Before the industrial revolution, when books were not yet mass commodities, the lecture method was the only way to transfer information from one generation to the next."

Academia barely noticed the industrial revolution, but a group of independent, like-minded pioneers, including Thrun and Mazur, are plunging it into the information revolution. By taking the lecture out of the hall and replacing it with online, interactive content studied at home, teaching time is spent on just that – teaching, not declaiming. And once the university is flipped, it's open to the entire world.

In July 2008, Daphne Koller was in a Google Faculty Summit at Mountain View, which gathers computer scientists from academic institutions around the US. Koller is a professor in computer science at Stanford; she enrolled at the Hebrew University of Jerusalem at 13, and now studies how Bayesian probability theory can be applied to genetics. The main topic at the summit was YouTube. "I said, 'Wait a minute, if we have this capability of producing videos at a very large scale – available to so many people so easily – why shouldn't we do that with our classes?'" recalls Koller. "Instead of having to give the same lecture 15 years in a row, I can take that lecture, chop it up so that the units correspond to cognitive modules that are easier for a student to assimilate, and augment it with interactive components."

Instead of sitting passively in lecture halls, her students, Koller thought, could watch videos which would also include interactive, question-and-answer elements in their own time. Face-to-face time would remain, but instead of a one-way propagation of information, it would become a "much deeper interaction" – case studies, discussions about particular problems. Koller took her idea to John Bravman, the vice-provost of education at Stanford, who took her to John Hennessy, the university's president. Hennessy gave Koller $100,000 (£63,000) to develop new software; her course would be the first pilot.

Koller sold the idea to her 170-strong class, but implementing it was a challenge, despite another $200,000 in funding from Google and various seed programmes. She had to create the online content and technical back-end, as well as a completely new teaching method. "It wasn't the smoothest sailing; we had technical issues," she says. But surveys completed at the end of the term showed that nearly three-quarters of the class preferred the new method.

Flip teaching is essentially a type of tutoring. The difference is that new digital tools enable teachers to coach large classes: one-on-one tutoring, scaled by the web. It was likely first described in 2000, by J Wesley Baker, a researcher at Cedarville University, Ohio, in his paper *The Classroom Flip: Using web course management tools to become the guide by the side.*

Although unaware of Baker's research, Koller applied the model to higher education. The flipped university worked, and other experiments confirmed this. Eric Mazur, at Harvard, had been trying the method in his classroom and found that, judged on pre- and post-test scoring, learning gains nearly tripled in his class once he began "to turn [the] traditional information-transfer model of education upside down". (He published early findings from his classroom and others around the world in *The Physics Teacher* journal in 2002.) A paper published in *Science* by researchers at the University of British Columbia in April 2011 found that students using an experimental flip-learning approach did more than twice as well as those using traditional methods. Koller found another benefit. "Once you start gathering data at the level that one can in these online systems – every click, where do students pause, where do they rewind you get these amazing datasets that tell you so much about how people learn. That's a tremendous opportunity to refine the way we teach, both at the global level and the individual." This data is real-time: Koller found herself adjusting classes based on how students had done on the test, what she calls "just-in-time teaching".

Koller had flipped her lecture hall. The next step would be to open its doors to the world. "Once you have a set of video content with integrated activities and assessments, you can make the same content available to those not fortunate enough to attend the Stanfords and Oxfords of the world."

Thrun was aware of Koller's work at Stanford, but not particularly impressed by it. "It didn't inspire me," says Thrun. "She tried to fix something that didn't seem to require much fixing, and the students' responses were mixed." But in March 2011, Thrun watched as Salman Khan took the stage at TED in Long Beach, California. The Khan Academy founder told the story of his nearly six-year-old website, which provides more than 2,800 tutorial videos in subjects such as science, maths and economics. Khan had started filming videos to tutor his 13-year-old cousin, who lived on the other side of the US from him, in maths. His approach was lo-fi: he would talk through the material while sketching out visuals on Microsoft Paint. Khan hosted the videos, which still preserve the Sellotaped-together feel of his original lessons, on YouTube. Word rapidly spread over the rest of the globe. Khan ended his TED talk by describing the academy as a "global one-world classroom". Joining him onstage, Bill Gates called the Khan Academy "the future of education".

iPad extra!
Download the WIRED app to read Steven Leckart's course review

The idea that new technology could open up higher education to a mass audience is not a new one. In 1926, John Stobart, director of education at the BBC, wrote a letter to the corporation's director general, John Reith, describing a new idea that he called "the wireless university". Stobart started with a question: "Are we to place broadcasting at the disposal of the various existing universities, or are we going to break out on a new trail of our own?" He complained that those current courses had "grown out of various historical sources such as the medieval trivium in the older universities". Citing the "ubiquity" of radio, Stobart wrote that the "wireless university, working under its different conditions, should, as far as possible, break away from tradition." Stobart asked Reith to think the notion over while he was in Scotland, admitting that his proposal was, for now, a "fantasy" – "a Wellsian sketch of possibilities". The Open University (OU), founded in 1969 in Milton Keynes, drew on Stobart's vision, working with the BBC to broadcast educational programmes. Despite being described as "blithering nonsense" by future prime minister Edward Heath, OU pioneered distance teaching and still has around 250,000 registered students, the vast majority in the UK.

Thrun, inspired by the ubiquity and interactivity of the web, would set about turning Stobart's fantasy into reality. Back at Stanford after TED, he dusted off a PowerPoint presentation he'd put together in 2007. Back then he had begun envisioning a YouTube for education, a for-profit startup that would allow students to discover and take courses from top professors. In a few slides, he'd spelled out the nine essential components of a university education: admissions, lectures, peer interaction, professor interaction, problem-solving, assignments, exams, deadlines and certification. Although Thrun admired MIT's OpenCourseWare – the university's decade-old initiative to publish online all of its lectures, syllabi and homework from 2,100 courses – he thought it relied too heavily on videos of actual classroom lectures. That was tapping just one-ninth of the equation, with a bit of course material thrown in as a bonus.

Thrun knew first-hand what it was like to crave superior instruction. When he was a masters-degree student at the University of Bonn in Germany in the late 80s, he found his AI professors to be lacking. He spent a lot of time filling in the gaps at the library, but he longed for a more direct connection to the experts. Thrun created his PowerPoint presentation because he understood that university education was a system in need of disruption. But it wasn't until he heard Khan's talk that he thought he could do something about it. He spoke with Peter Norvig, Google's director of research and his CS221 coprofessor, and they agreed to open up their next class. It was an educational experiment, but Thrun realised that it could also be the first step in turning that old PowerPoint into an actual business.

In June he took the next step: cofounding KnowLabs, which he funded with

UDACITY FOUNDERS **SEBASTIAN THRUN** (*STANDING*) AND **PETER NORVIG** IN THE BASEMENT OF THRUN'S GUESTHOUSE, WHERE THEY RECORD TUTORIALS FOR THEIR STUDENTS

PHOTOGRAPHY: SAM COMEN; PREVIOUS SPREAD, LEFT, REX

$300,000 of his own money. He pulled in David Stavens, one of Stanley's cocreators, as CEO, and he tapped Stanford robotics researcher Mike Sokolsky to be CTO. They converted Thrun's guesthouse into a temporary office. Once ensconced on a scenic hillside on Page Mill Road near Stanford's campus, the team began planning. They had eight weeks before the autumn term started – not unreasonable given the modest scope of the project. By late July, 5,000 students had signed up. A few days later the class numbered 10,000. And then Stanford called.

Thrun had neglected to tell them about his plan – he'd had a hunch it might not go down well. The university's chief complaint: you cannot issue an official certificate. Over the next few weeks, 15 meetings were held on the matter. Meanwhile, enrollment in CS221 was ballooning: just two weeks later, numbers totalled 58,000. In the 15 meetings, not one person objected to Thrun's offering his class online for free. The administration simply wanted him to drop the assignments and certificate. He refused. Those two components, he argued, were responsible for driving signups. Eventually they reached a compromise: offer a statement of accomplishment, not a certificate; and include a disclaimer stating that the class wouldn't count toward Stanford credit, grade or degree.

By mid-August, word of his AI class went viral after a write-up in *The New York Times*. Enrolment passed 100,000. KnowLabs' website had been built to handle 10,000 students. Class was starting in a matter of weeks. "That," Sokolsky says, "is when I stopped sleeping."

> 'YOU SHOULD BE ABLE TO DO A DEGREE ON A SMARTPHONE'
>
> NIALL SCLATER, OPEN UNIVERSITY

Thrun is thrilled. His experiment is working. More than 20,000 students have taken the midterm and are turning in weekly assignments. The website's stability is improving. CS221's YouTube videos have been viewed five million times. The team at KnowLabs has automated and ramped up workflow: film, edit, double-check the lessons, post and monitor the message boards.

The course is hitting eight of Thrun's nine educational components. They've hired a second engineer, who also serves as a teaching assistant to oversee the discussion forums, and in November they took on a video editor and a web designer to rethink the interface for future courses. In December the company secured funding from Charles River Ventures, a VC firm specialising in early-stage investments. First order of business: another hiring spree, which more than doubles the staff, bringing it to 14. KnowLabs revamped its software from scratch and started to work on a full site redesign.

KnowLabs already has competition, and it's close to home. Of the three Stanford computer-science courses being offered to the public, two use Daphne Koller's platform. Neither has attracted anything like the number of enrolees CS221 has, but some students taking all three classes say the materials and website for CS221 are less polished. And where Thrun is stepping down from teaching at Stanford to launch KnowLabs, Koller and Andrew Ng (the professor who taught CS221 before Thrun and Norvig) are developing software for their own venture, Coursera, an independent platform for serving online courses, with the blessing of Stanford. The plan is to offer 14 classes in 2012, including cryptography, anatomy and game theory. For now, these are all free.

On the other side of the US, MIT has announced that it is creating MITx, which will serve up a handful of online courses this autumn. Enrolment and participation will be free, but to earn a certificate of completion students will have to pay a "modest" fee. In March, TED-Ed launches its own free education platform offering six-minute videos; in April, it will start providing interactive tools for teachers, so that they can either pull video content from YouTube and TED-Ed, which comes with lesson plans, or create their own videos, and combine these with online quizzes (their own or provided by TED) to create customised lessons.

In the UK, the OU is embracing digital tools such as Moodle, an open-source "virtual learning environment"; it has had nearly 48 million downloads on iTunesU, Apple's higher-education content hosting service. "My philosophy is that you should be able to do an entire degree on an Android phone or iPhone," says Niall Sclater, director of learning, teaching and quality at OU. "And the ebook platform is evolving rapidly: you can imagine more interactivity, where you have a forum within an ebook, so at the end of a chapter you discuss it with other students."

LOG ON: SEATS OF FLIP LEARNING

KHAN ACADEMY

The Khan Academy was founded by MIT engineering graduate Salman Khan in 2006. The website supplies free first-person tutorials on subjects as varied as economics, art history and computer science. Financial donors to the academy include the Bill & Melinda Gates Foundation, Google and the O'Sullivan Foundation. *khanacademy.org*

UDACITY

When Stanford professor Sebastian Thrun posted a free AI course online last year, it attracted more than 160,000 students from 190 countries. The experiment prompted Thrun and two other roboticists to launch the for-profit online "college", Udacity. Courses offered include Building a Search Engine and Programming a Robotic Car. *udacity.com*

CODECADEMY

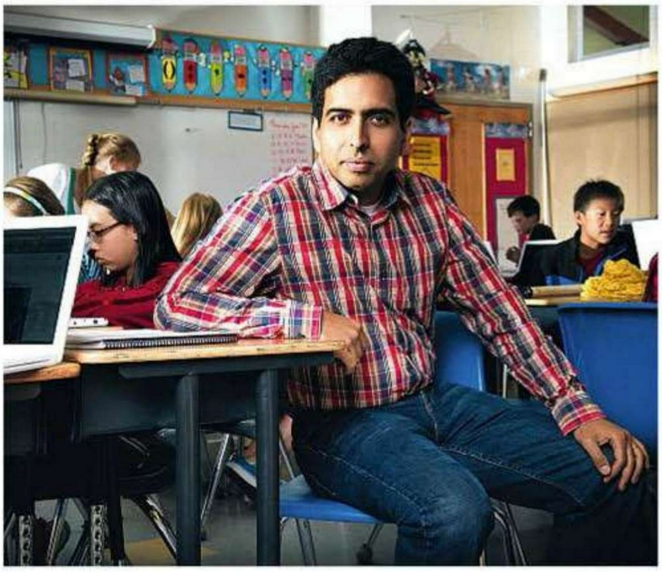
Launched by Y Combinator graduates Zach Sima and Ryan Bubinski in August 2011, Codecademy teaches people how to program in multiple computing languages quickly, easily and for free. Their approach teaches by talking students through the processes – you write code while being led through the basic principles. *codecademy.com*

OPENLEARN

UK-based distance-learning institution the Open University joined the democratic education wave in 2006 with OpenLearn, a website that provides free global access to the OU professors' learning materials. This includes more than 600 courses divided into topics spanning from Body & Mind to Money & Management *open.edu/openlearn*

TED-Ed

TED wants its ideas to spread even further, to "brains that aren't fully wired yet", according to curator Chris Anderson. The TED-Ed hub combines instructional videos with interactive content and lesson plans designed by educators. Teachers can submit audio lessons to the site: the best recordings will be turned into new videos and win their maker $1,000. *education.ted.com*



SALMAN KHAN (*PICTURED*) FIRST SENT TUTORIAL VIDEOS TO HIS LONG-DISTANCE COUSIN. KHAN ACADEMY VIDEOS HAVE SINCE ATTRACTED 125 MILLION VIEWS

Thrun isn't worried that these respected seats of learning will crush his startup. He's envisioning his own digital university, with a less conventional curriculum; one based on solving problems, not lectures on abstract topics. It would offer a viable alternative for students of the global one-world classroom – particularly those who lack the resources to move to the US and attend college.

KnowLabs recently launched an online platform called Udacity. The name, a mashup of audacity and university, is intended to convey the boldness of both Thrun's and his students' ambitions. His goal is for Udacity to offer free eight-week online courses. For the next six months or more, the curriculum will focus on computer science. Eventually it will expand into other quantitative disciplines including engineering, physics and chemistry. The idea is to create a menu of high-quality courses that can be re-run and improved with minimal involvement from the original instructor. KnowLabs will work only with top professors who are willing to put in the effort to create dynamic, interactive videos. Just as Hollywood cinematography revolutionised the way we tell stories, Thrun sees a new grammar of instruction and learning starting to emerge as he and his team create the videos and other class materials. Behind every Udacity class will be a production team, not unlike a film crew. The professor will become an actor-producer. Which makes Thrun the studio head.

Thrun's venture is deliberately radical. His homepage states: "I am against education that is only available to the top one per cent of all students. I am against tens of thousands of dollars of tuition expenses. I am against the imbalance that the present system brings to the world. I want to empower the 99 per cent." He imagines that in ten years' time, job applicants will tout their Udacity degrees. In 50 years, he says, there will be only ten institutions in the world delivering higher education – and Udacity has a shot at being one of them.

But Udacity, along with any for-profit education company, will need a business model. The OU's Sclater says that, at the moment, this lies in the last ninth of Thrun's university criteria: qualification. "The business model is mainly around students obtaining qualifications," says Sclater. Will people pay for a Udacity degree? "Verification is the problem: are employers going to be prepared to accept self-certified qualifications?"

However, the old university business model may not apply. "People will start to buy smaller chunks of learning," according to Sclater. He says that the OU uses a freemium model, where free content on iTunesU and YouTube drives people to sign up. "Employers will pay their staff to go and learn a particular topic." Koller adds that, at universities, less expensive physical courses could be supplemented by resources such as Coursera's.

KnowLabs's Stavens is also thinking about the business of university 2.0. Though Thrun cringes at the "one per cent" notion of charging students, people might eventually pay for add-ons – study aids, say, or offline materials. He also considers other revenue streams. Near the end of the CS221 term, he emails his top 1,000 students, the ones with perfect or near-perfect scores on homework and tests. The subject: Job Placement Programme. Thrun solicited résumés and promised to get the best ones into the right hands at tech companies, including Google. A recruiter who places a hire typically earns ten to 30 per cent of an engineer's first-year salary, which might be $100,000. Stavens figures he could charge much less. After all, KnowLabs discovers talent in the course of doing business.

It's the last day of Thrun and Norvig's Stanford class and Thrun steps up to a podium to deliver a lecture. Only 41 students out of 200 show up. Four stroll in late. Two fall asleep. Five leave early. That's not uncommon. During the autumn term, the Stanford students taking CS221 preferred watching the KnowLabs videos. In previous years his students averaged 60 per cent on the midterm exam; this time around they did much better. The class averaged 83 per cent overall.

He doesn't congratulate himself for long. He acknowledges some harsh feedback from his students. "We made a lot of mistakes," he says. "In the beginning I made each problem available only once. I got an email from a student saying, 'You're behaving like one of these arrogant Stanford professors looking to weed out students.' I realised we should set up the student for success, not failure." KnowLabs tweaked the software to allow students to keep retrying problems.

Koller had her critics, too: "Some of my students said: 'If I wanted an online education, I wouldn't have come to Stanford.' It's a reactionary point of view. But with every revolution, you're going to have people who prefer to stick to the old ways." W

Steven Leckart is a correspondent for WIRED *US. Visit wired.co.uk for his impressions of taking the AI course. Tom Cheshire wrote about Tumblr's David Karp in 03.12*

PHOTOGRAPHY: JOE PUGLIESE

WHERE INSPIRATION STRUCK

HISTORY CELEBRATES THE DISCOVERY OF DNA AND OXYGEN – BUT WHAT OF THE DESKS OR STREET CORNERS WHERE SUCH BOLD IDEAS WERE REFINED? JOIN US ON A TOUR OF BRITAIN'S *OTHER* SITES OF SPECIAL SCIENTIFIC INTEREST

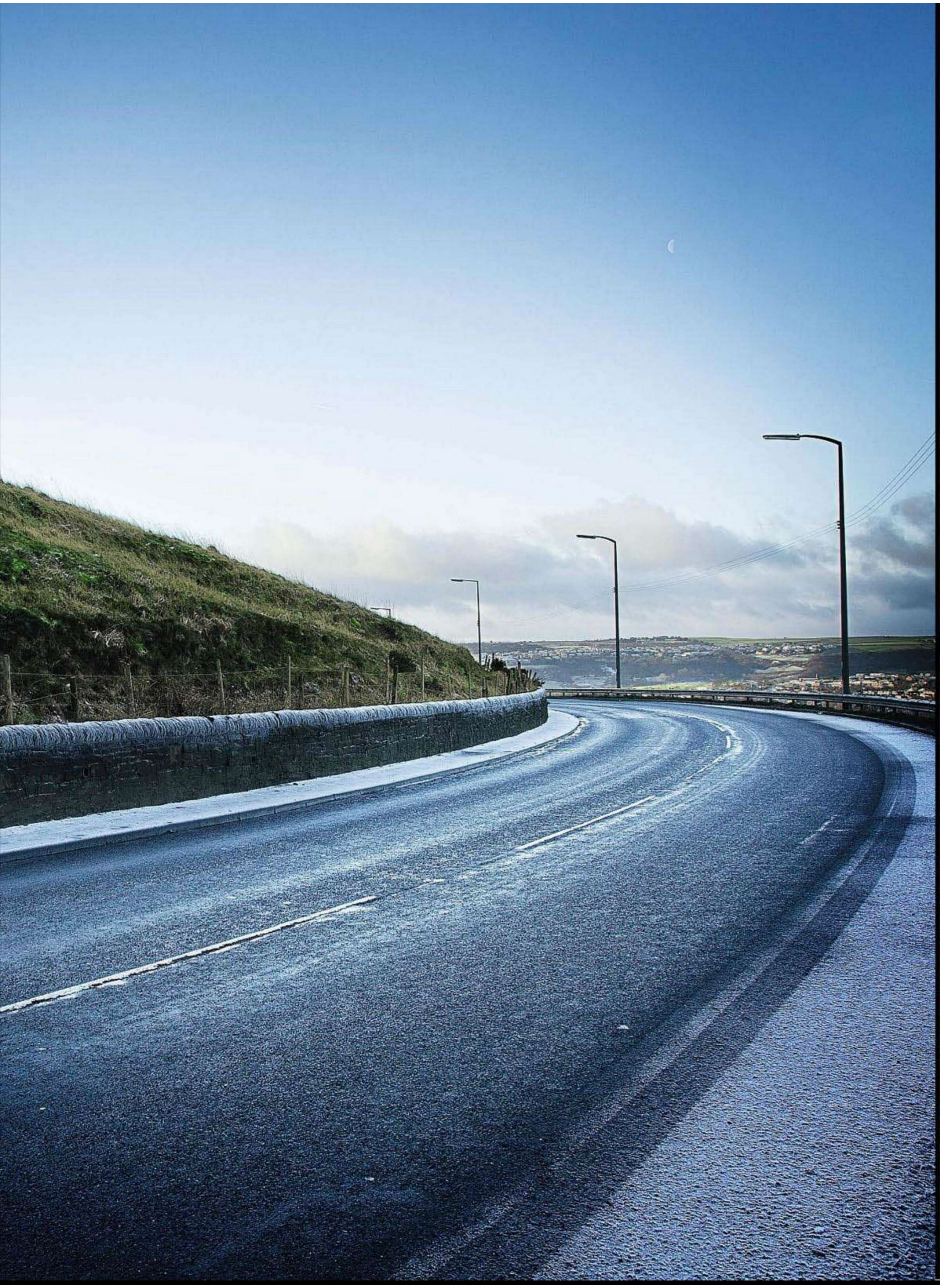
Photography: CHRISTOFFER RUDQUIST
Research: DAN SMITH

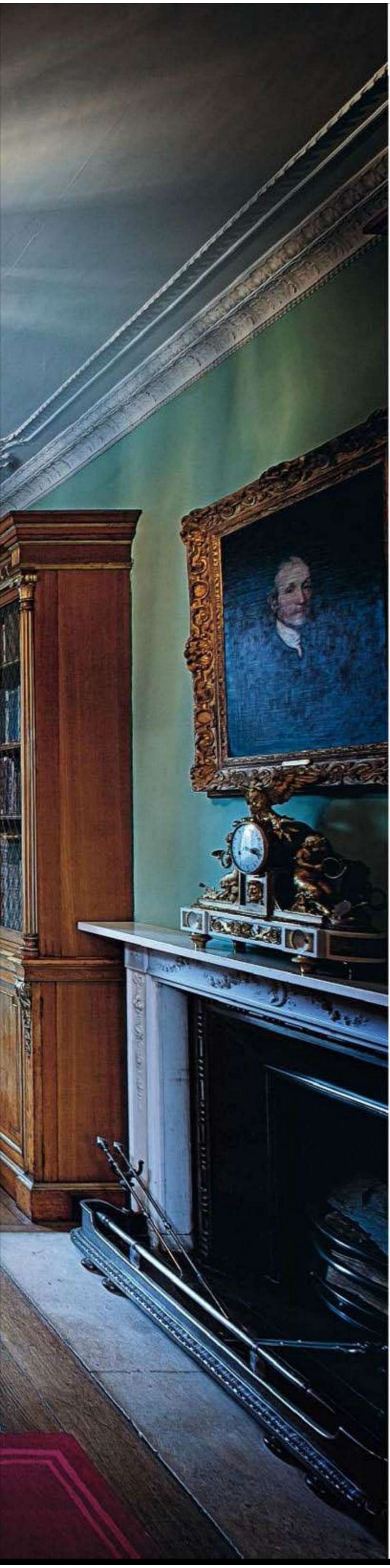
History records humanity's great scientific leaps forward, but what of the places that inspired them, or the locations that played host to these momentous events? Some are specially built to stimulate thought, such as Charles Darwin's peaceful woodland path; others were designed for exploration, such as the Cavendish Laboratory at Cambridge University. Some places inspired by accident: stepping off the pavement in Russell Square, Leó Szilárd theorised nuclear chain reaction; navigating a foggy road preceded the invention of Catseyes. WIRED tours some of the hidden locations that played a significant role in creating Britain's scientific heritage.

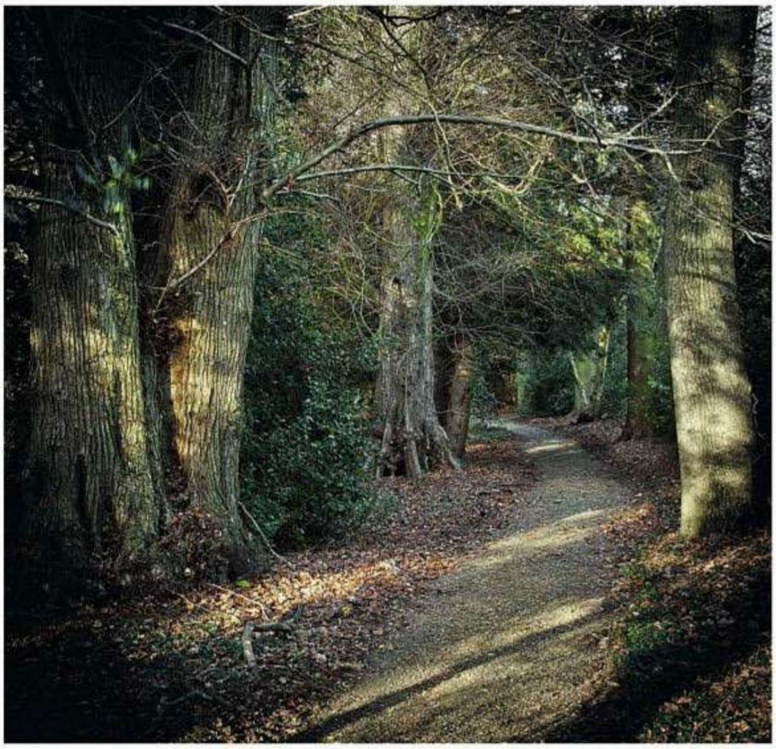
CATSEYES

Queensbury Road
(the A647), West Yorkshire
+53° 45' 5.72", -1° 52' 5.71"

One evening in 1933, Percy Shaw was driving home to Halifax from the Old Dolphin pub in Queensbury, West Yorkshire. At around 300m above sea level, the A647 was foggy and damp. Previously, Shaw had relied on the reflections of his car's headlights on the metal tramlines to guide him, but the trams had recently been discontinued and the lines dug up. That evening, his headlights were reflected in the eyes of a cat, giving him the idea for his 1935 invention. The Catseye design is still in use: four mirror-coated reflective lenses embedded in a rubber cap, which sits inside a metal base. If the Catseyes are run over, a wiper cleans them as they sink into the often water-filled base.







OXYGEN

Bowood House,
Chippenham, Wiltshire
+51° 25' 42.36", -2° 2' 15.77"

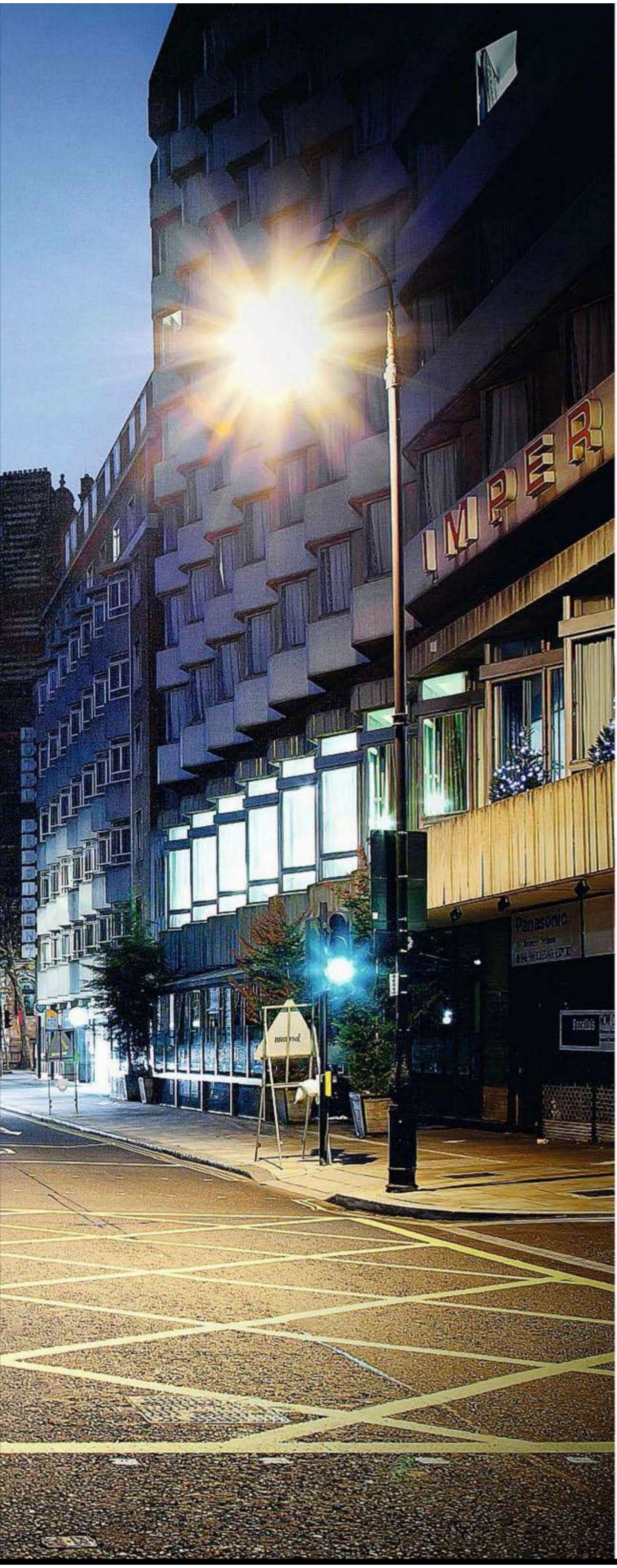
The 18th-century country estate of Bowood House is where Joseph Priestley discovered "dephlogisticated air", the gas now known as oxygen. He was a Unitarian minister, teacher, author, natural philosopher and, between 1773 and 1780, the librarian and literary companion of Lord Shelbourne. The earl built a laboratory at Bowood in which Priestley devised an experiment to focus the Sun's rays on to a sample of mercury oxide (HgO). This released a gas that, wrote Priestley, was "five or six times better than common air for the purpose of respiration, inflammation, and, I believe, every other use of common atmospherical air."

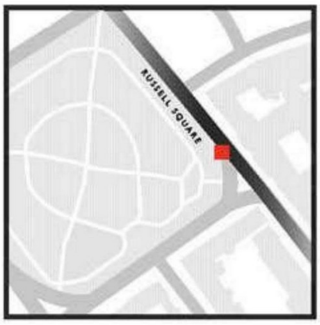
NATURAL SELECTION

Down House,
Biggin Hill, Kent
+51° 19' 52.13", +0° 3' 11.91"

Charles Darwin moved to Down House, near Biggin Hill in Kent, in September 1842 – six years after he'd finished his around-the-world voyage aboard *HMS Beagle*. While there he commissioned a circular path in a small section of the seven-hectare grounds – a tree-lined route used daily as his "thinking path". Walking circuits, Darwin pondered his theories, refining the ideas that would form his masterpiece, *On the Origin of Species by Means of Natural Selection* (1859). The path remains, as does his "weed garden", a selection of foliage he used to test his hypothesis of natural selection. Charles Darwin died at Down House, aged 73.

FOR BEDFORD WA
AND BERNARD ST
FOLLOW DIVERSION
Diversion





CHAIN REACTIONS

Russell Square, Holborn, London
+51° 31' 18.65", -0° 7' 28.44"

After the Nazis' rise to power in 1933, Jewish Hungarian physicist Leó Szilárd left Berlin for London. On the morning of September 12 that same year he read, in *The Times*, the words of physicist Ernest Rutherford: "...anyone who looked for a source of power in the transformation of the atom was talking moonshine." Szilárd waited as traffic rushed along Southampton Row, Holborn. "I crossed the street," he recalled later. "It suddenly occurred to me that if we could find an element which is split by neutrons and which would emit two neutrons when it absorbed one neutron, such an element, if assembled in sufficiently large mass, could sustain a nuclear chain reaction."

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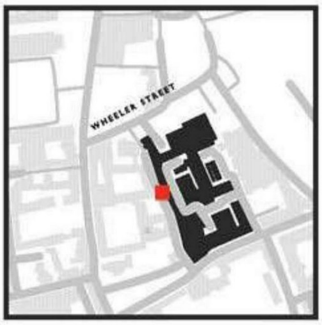
DNA

Cavendish Laboratory, Cambridge University
+52° 12' 12.56", +0° 7' 7.72"

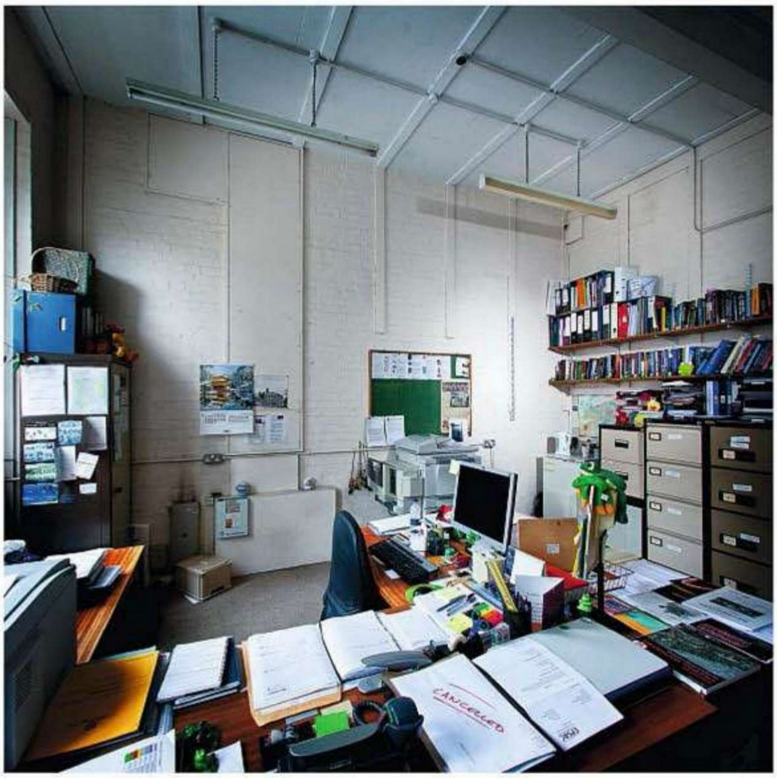
"We have discovered the secret of life," announced Francis Crick as he walked into The Eagle pub in Cambridge on February 28, 1953, flanked by James Watson. Crick referred to the pair's discovery of the structure of DNA, theorised over in the Cavendish Laboratory. Earlier alumni of Cambridge, such as Isaac Newton, carried out their research in their colleges, as there had been no dedicated research lab. In 1874 William Cavendish, the university's chancellor, donated £6,300 to build one. The Cavendish has produced many notables including JJ Thomson, who discovered the electron in 1897; Francis Aston, who recognised isotopes; and Stephen Hawking.

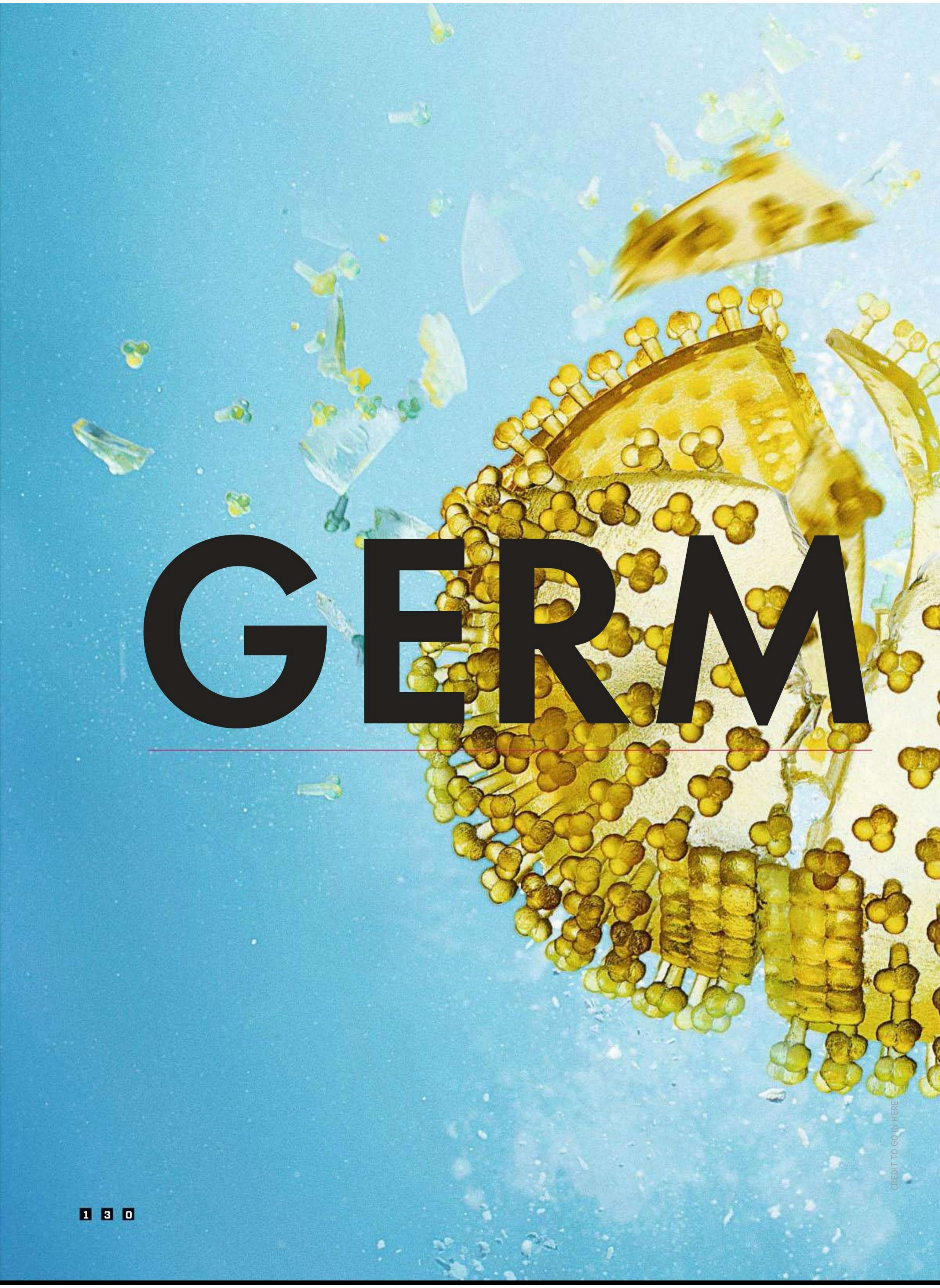


TRANSATLANTIC TRANSMISSION

Poldhu Wireless Station, Cornwall
+50° 1' 47.15", -5° 15' 46.45"

Guglielmo Marconi had already been conducting wireless communication experiments for several years, but this field is where, on December 12, 1901, he sent the first transatlantic wireless transmission. Morse code for the letter S was transmitted from two 51m-high masts and received 3,500km away on what's now Signal Hill, in Newfoundland, Canada. "The chief question was whether wireless waves would be stopped by the curvature of the Earth," he noted. "The first and final answer came at 12:30 when I heard... dot... dot... dot." All that remains are outlines of the station's foundations and a modest monument to Marconi.





GERM

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warfare

PHOTOGRAPHY: STAN MUSILEK

A NEW GENERATION OF DRUGS COULD BLAST ANY VIRAL DISEASE – FROM HIV TO THE COMMON COLD. SHOULD WE PULL THE TRIGGER?

BY CARL ZIMMER

CREDIT TO GO IN HERE

There's a moment in the history of medicine

that's so cinematic it's a wonder no one has put it in a Hollywood film. The scene is a London laboratory in 1928. Alexander Fleming, a Scottish microbiologist, is back from a holiday and is cleaning up his work space. He notices that a speck of mould has invaded one of his cultures of *Staphylococcus* bacteria. But it isn't just spreading through the culture. It's killing the bacteria surrounding it.

Fleming rescued the culture and carefully isolated the mould. He ran a series of experiments confirming that it was producing a *Staphylococcus*-killing molecule. Then he discovered that the mould could kill many other species of infectious bacteria as well. "I had a clue that here was something good, but I could not possibly know how good it was," he later said.

No one at the time could have known how good penicillin was. In 1928, even a minor wound was a potential death sentence, because doctors were mostly helpless to stop bacterial infections. Through his investigations into that peculiar mould, Fleming became the first scientist to discover an antibiotic – an innovation that would eventually win him the Nobel Prize. Penicillin saved countless lives, killing off pathogens from staph to syphilis but causing few side effects. His work led other scientists to seek out and identify more antibiotics, which helped to change the rules of medicine. Doctors could prescribe drugs that effectively wiped out most bacteria, without even knowing what kind of bacteria were making their patients ill.

Of course, even if bacterial infections were totally eliminated, we would still get sick. Viruses – which cause their own panoply of diseases, from the common cold and the flu to Aids and Ebola – are profoundly different from bacteria, so they don't present the same targets for a drug to hit. Penicillin interferes with the growth of bacterial cell walls, for example, but viruses aren't even cells – they're just genes packed into "shells" made of protein. Other antibiotics, such as streptomycin, attack bacterial ribosomes, the protein-making factories inside the pathogens. A virus doesn't have ribosomes; it hijacks the ribosomes inside its host cell to make the proteins it needs.

We do currently have "antiviral" drugs, but they're a pale shadow of their bacteria-fighting counterparts. People infected with HIV, for example, can avoid developing Aids by taking a cocktail of antiviral drugs. But if they stop taking them, the virus will rebound to its former level in a matter of weeks. Patients have to take the drugs for the rest of their lives to prevent the virus from wiping out their immune system.

Viruses mutate much faster than bacteria, so current antivirals have a limited shelf life. And they all have a narrow scope of attack. You might treat your flu with Tamiflu, but it won't cure you of dengue fever or Japanese encephalitis. Scientists have to develop antivirals one disease at a time – a labour that can take many years. As a result, we still have no antivirals for many of the world's nastiest viruses.

Virologists are still waiting for their Penicillin Moment. But they might not have to wait forever. Buoyed by advances in molecular biology, a handful of researchers in labs around the US and Canada are homing in on strategies that could eliminate not just individual viruses, but any virus, wiping out viral infections with the same efficiency that penicillin and ciproflaxacin bring to the fight against bacteria. If these scientists succeed, future generations may struggle to imagine a time when we were at the mercy of viruses, just as we struggle to imagine a time before antibiotics.

Three teams in particular are zeroing in on new antiviral strategies, with each taking a different approach to the problem. But at root they are all targeting our own physiology, the aspects of our cell biology that allow viruses to take hold and reproduce. If even one of these approaches pans out, we might be able to eradicate any type of virus we want. Some day we might even be faced with a question that today sounds absurd: are there viruses that need protecting?

At 5am one day last autumn, in San Francisco's South of Market district, Vishwanath Lingappa was making rabies soup. At his lab station, he injected a syringe full of rabies virus proteins into a warm flask loaded with other proteins, lipids, building blocks of DNA, and various other molecules from ground-up cells. It cooked for hours on Lingappa's bench, and occasionally he withdrew a few drops to analyse its chemistry. By spinning the fluid in a centrifuge, he could isolate small clumps of proteins that flew towards the edge as the bigger ones stayed close to the centre.

To his mix, Lingappa had added a particular protein he wanted to study. He suspected that the rabies virus used this protein in the infected cell to assemble the capsid, or external shell, of replicated viruses. He tagged the target protein with radioactive atoms, allowing him to follow it as it interacted with other elements.

At 10am, Lingappa took pictures of the mixture. By lunchtime, the images were ready to show to his staff. In the conference room, a table was strewn with take-out sandwiches, and an abandoned bowl of porridge sat on a sideboard. As Lingappa held up the films to the light, his colleagues crowded behind him to make out black streaks across the images.

As predicted, the tagged protein had joined with other proteins, creating the microscopic machines that in a real infection would assemble the rabies virus shell. Why would this matter? Because a drug developed by Lingappa's firm, Prosetta Antiviral, has been shown to interfere with this protein, blocking it from functioning in these shell-making machines. If his gamble pays off, this is the pathway by which an antiviral drug will stop cells from replicating the rabies virus.

Lingappa came relatively late to his obsession with antivirals. He trained as a cell biologist in the late 70s in the laboratory of Günter Blobel, a Rockefeller University cell biologist who went on to win the Nobel Prize in 1999. Blobel studied how cells work by grinding them up and running experiments on their loose contents. This type of cellular soup, known as a cell-free system, can simulate the inner workings of a cell, including the assembly of new genes and proteins. By adjusting its composition – leaving out a single enzyme, for example – scientists can figure out how a cell's molecules work together to keep it alive. Under Blobel's tutelage, Lingappa became a cellular *chef de cuisine* in his own right. For example, he ran experiments to figure out how newly made proteins were ferried through a cell to the place where they were needed. After earning his PhD, Lingappa headed west to UC San Francisco to continue his research.

He might have experimented his way to a quiet retirement had it not been for his younger sister Jaisri, who was treating Aids patients at the UCSF Medical Center. She spent a summer at Rockefeller many years beforehand, at her brother's urging, and now saw that cell-free systems might shed some light on viruses. At the time, the prevailing dogma was that once a host cell made new virus genes, the capsid could self-assemble around them. But Jaisri was sceptical. She suspected that viruses needed help from host enzymes to mould the shell into its proper shape. By experimenting in a cell-free system, she reasoned, she might be able to identify those host enzymes that the virus depended upon – and figure out how to block them. She asked her brother whether there was any chance her idea could work. "I haven't a clue," Vishwanath replied. "Let's try it."

Battling the virus

A brief history

1500s

Doctors in India use an early version of vaccination against smallpox, using dried pus from smallpox sores.

1721

Lady Mary Wortley Montagu (below) introduces smallpox variolation – direct exposure to dried pus or sores.

1774

Benjamin Jesty, an English cattle breeder, inoculates his family with cowpox to protect them from smallpox.

1885

Louis Pasteur (below) invents a rabies vaccine using a laboratory-weakened strain of the target virus.

1939

Industrial-scale production of penicillin begins following inroads made by Oxford biologists Howard Florey and Ernst Chain.

1944

American virologist Wendell Stanley reports that penicillin and other antibiotics have no effect on viruses.

1957

Interferons, antiviral proteins produced by infected cells, are discovered. They are hailed as a miracle but prove risky.

1959

William Prusoff discovers idoxuridine, the first effective antiviral. It can only be used topically because of side effects.

The Lingappas began their experiments on hepatitis B, a relatively simple virus that scientists already knew a great deal about. They figured out how to get cell-free systems to generate hepatitis B capsids. Next they tinkered with the soup's recipe, taking out various enzymes and observing whether there was any change to the shells it produced. Before long they had found that a number of enzymes were essential to making the capsids. When these enzymes were present, the cell-free system produced perfect shells. Without them the system could manage only stunted, half-formed shells.

They and their colleagues went on to run the same experiments on HIV, and again found that the viruses needed lots of help. Host enzymes had to join together to form complicated biological machines with the right shape – the right set of pockets, grooves and clefts – to grab parts of viruses and push them into their proper place to build the shell. For each capsid-making machine, the Lingappas reasoned, there should be a molecule they could lodge in some key pocket, making it useless for hauling capsid proteins into place. The machine would thereby be immobilised, and the infected cell could no longer build viruses. By 2003, Vishwanath had so much faith in his idea that he launched Prosetta.

The first thing researchers at Prosetta had to do was search for promising candidates – molecules of just the right shape to lodge into the capsid-making machinery. They screened 80,000 compounds by testing each in a cell-free system. Most couldn't stop capsids from forming, but a few dozen did. Instead of focusing on one, Lingappa decided to pursue almost all of them on the premise that a victory against any one virus would help Prosetta extend its strategy to all of them.

It was a gutsy strategy, and so far it's paying off. Studies – in both cell cultures and on animals – are showing that Prosetta's approach can stop rabies, Ebola, influenza and a number of other viruses. If, as Lingappa suspects, all viruses need help from their host cells to assemble, he may have found a strategy that can work against every virus that could ever make us sick.

Up until now, antiviral drugs have tended to work by interfering with viruses themselves. Consider the case of Tamiflu, our best drug against influenza after infection has already occurred. Tamiflu binds to neuraminidase, a protein on the surface of flu viruses. When new viruses form, they use

PHOTOGRAPHY: GETTY; CORBIS

neuraminidase to pry open a passageway out of their host cell. Tamiflu disables the protein, trapping the flu viruses so that they can't spread. The shape of the molecule in Tamiflu is exquisitely well matched to the neuraminidase protein on flu viruses, and as a result it can't bind to proteins on the surface of other viruses.

The Tamiflu strategy – targeting the components of individual viruses – can yield effective drugs, but it also has some serious drawbacks. The biggest of these is resistance. Many viruses, such as the flu and HIV, mutate at a blinding pace: a million times faster than our own genome does. Every now and then, one of those mutations will alter the target of an antiviral drug. The drug will have a harder time latching on to the mutant virus, which will then be free to reproduce and flourish unchecked. In 2007, for instance, a mutant form of flu virus emerged that could resist Tamiflu. It had evolved a differently shaped neuraminidase that Tamiflu couldn't grab. So even as governments around the world stockpiled 200 million doses of the drug to prepare for the next great flu pandemic, Tamiflu-resistant strains spread across the world.

"It's a game-breaker," says Vincent Racaniello, a Columbia University virologist and the author of the textbook *Principles of Virology*. "Anything you make, the viruses will become resistant to."

Prosetta's approach is so intriguing because it alters our own cellular machinery instead of attacking the virus directly. Roughly speaking, this is the chief insight that animates all of the new strategies for antiviral drugs: they focus on the host instead of the virus. A second approach along these lines would boost our own immunological response to viruses, and a third strategy would take an even more radical step: rewiring our cells to commit suicide when they get infected.

That second approach is being spearheaded by Eleanor Fish of the University of Toronto. She and other researchers worldwide are developing drugs that might replace or supplement interferons, our own catch-all viral response proteins. Essentially the idea is to accelerate the body's own virus-killing powers. Our cells can sense a viral invasion because of a quirk in the way most viruses replicate: using the host cell's machinery, they copy their own genes by making a peculiar molecule called double-stranded RNA. So our cells are equipped with proteins whose sole job is to detect double-stranded RNA. When they do, they relay a signal throughout the cell that an intruder has invaded.

1964

Scientists get a hit: a compound called amantadine proves effective against influenza. It is approved in the late 60s.

1967

The World Health Organization (WHO) launches a campaign to eradicate smallpox, which kills 15m people a year.

1974

Acyclovir, an antiviral for herpes viruses, is discovered. It is now one of the most commonly used antiviral drugs.

1978

The last known death from smallpox occurs. In 1980, the WHO declares its eradication campaign a success.

1985

Scientists discover the first antiviral effective against HIV. Called AZT, it is later joined by a number of other drugs.

1989

AZT-resistant HIV strains are found. Doctors prescribe cocktails of antivirals to slow the evolution of resistance.

1996

Gilead Sciences researchers discover a new antiviral for influenza, marketed as Tamiflu.

2005

Scientists report influenza viruses that are resistant to Tamiflu. These strains have since spread around the world.

2011

FDA gives Vertex Pharmaceuticals and Merck approval for effective new antivirals for hepatitis C.

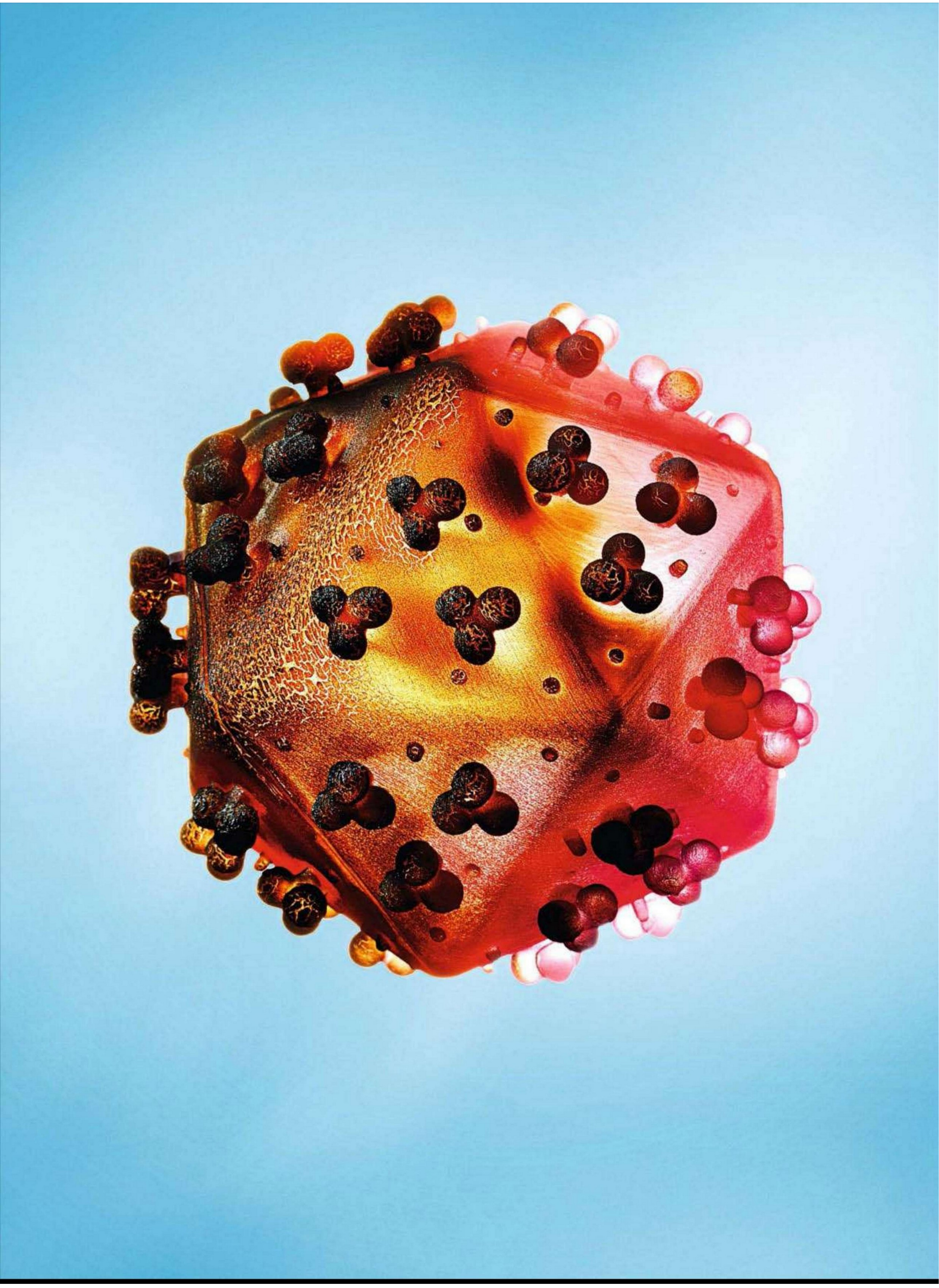
The cell then produces interferons, which in turn trigger the production of more than 300 other kinds of proteins, each with its own role to play in killing viruses. Some slice up the virus's genes and wreck its proteins. Others tell the cell to become rigid, making it harder for new viruses to escape. The infected cell also sends interferons to surrounding cells, creating a firebreak that stops the spread of the infection. "The very first response to a virus is an interferon response," Fish says. But our natural defences are far from perfect: viruses often replicate fast enough to keep ahead of the interferon patrol, and certain kinds of viruses, such as influenza and Sars, make proteins whose sole job is to shut down interferons. Since the 90s, some natural interferons have been approved for use against certain viruses (hepatitis C, for example), but their track record has been disappointing: they only work in some patients, they can cause toxic side effects, and they are expensive, delicate drugs.

So Fish and other groups of scientists are trying to build a drug that would do the interferons' job better. By tacking on polyethylene glycol – a cluster of hydrogen, carbon and oxygen atoms – they've created synthetic interferons that last days instead of hours and will wipe out hepatitis C viruses completely in up to 81 per cent of treated patients, depending on the strain. During Toronto's Sars outbreak, Fish tested synthetic interferons on a small pool of patients and found that their lungs healed significantly faster than those of control patients, allowing them to get off supplemental oxygen sooner. Like Lingappa, Fish has huge ambitions for these synthetics. If one of them succeeds, it could become a single drug to fight not just one virus or a few, but nearly every virus.

3D-printed models of influenza (*previous page*), HIV (*right*) and Ebola (*overleaf*) viruses

The third and arguably the most radical approach to broad-spectrum antivirals was conceived years ago by biological engineer Todd Rider. At MIT's Lincoln Laboratory in the late 90s, he built a technology called Canary, a sensor for dangerous airborne pathogens such as anthrax and smallpox. This ingenious box houses white blood cells, each of which is engineered to detect a particular kind of bacterium or virus. Canary is

PHOTOGRAPHY: CORBIS; DR D LOREN KETAI/CDC



now installed in several government buildings in the Washington DC area. But for all the success of his invention, the experience left him profoundly dissatisfied. “I realised that if we detected bacteria, it was fine,” Rider says. Doctors could prescribe antibiotics, after all. “But if we detected viruses, there really wasn’t anything out there.” He sensed an opportunity to create something. “I wanted a treatment that was broad spectrum, that was effective against a wide range of viruses, and that would be difficult for viruses to evolve resistance to,” he says.

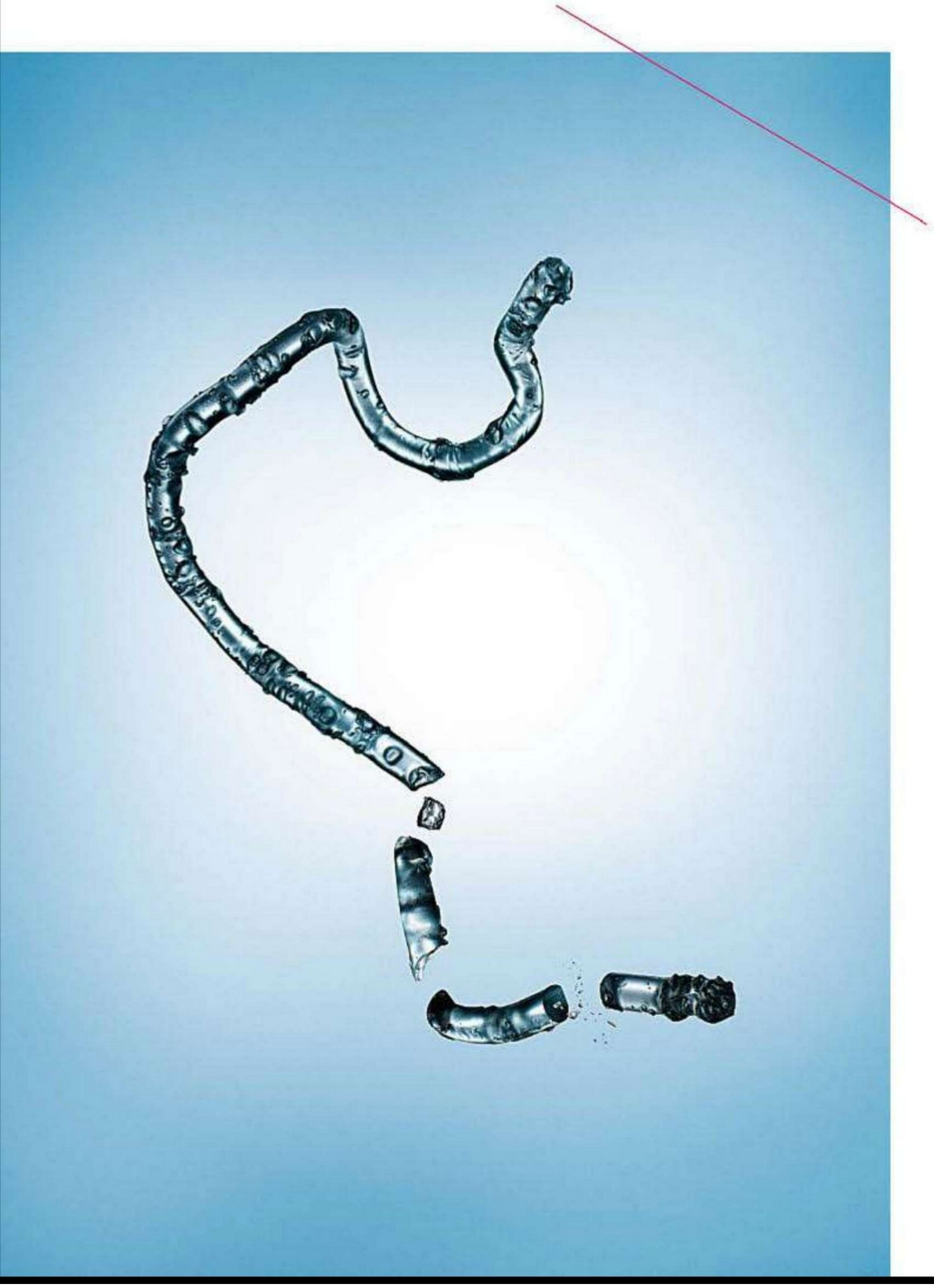
That something was an artificial protein. To make it, he would need to marry parts of two natural proteins. One string would detect double-stranded RNA, the telltale sign of most invading viruses. The other would lead the infected cell to kill itself. Rider wanted to make a poison pill for cells: a protein that, when it grabbed on to the double-stranded RNA of a virus, would trigger instant cellular suicide. That may sound like a dangerous kind of therapy, but our bodies already rely on it naturally to fight both infections and cancer.

Rider dubbed his theoretical molecule Draco, for double-stranded RNA activated caspase oligomeriser. On paper it looked great. Viruses that quickly evolve resistance to targeted antivirals would have no way of evading this weapon: doing so “would need a whole new set of genes,” Rider says.

In online databases, he found sequences for two genes that performed the functions he wanted to combine – detect double-stranded RNA and trigger apoptosis, or cell death – and then he joined the two into a single sequence. He gave his new protein an increasingly challenging series of tests. In one early experiment, he found that the protein could get inside cells and stay there for as long as 11 days.

Next he injected rhinoviruses (which cause the common cold) into ordinary human lung cells and lung cells carrying Draco. In the unprotected batches of cells, the rhino virus multiplied, spreading from cell to cell and wiping out the entire population. When Rider added the virus to the Draco-protected cells, the infected cells destroyed themselves right on cue; the rest were left unharmed.

To see how Draco would fare in a living body, he began to study it in mice. To deliver the drug to the right place in the mice’s bodies, Rider added a kind of molecular “address label” to the Draco protein such that the cells in a particular organ would be targeted. The mice seemed unharmed by the initial introduction. So Rider exposed the mice to flu viruses. Without Draco, four out of five mice died. But if he spritzed Draco into their nostrils just before or after the infection, they all lived.



Having published the results in *PLoS One* journal last July, Rider is now preparing to test Draco against haemorrhagic fever and other viruses in mice and hopes to license the technology to a company that can take it to human trials. Rider sees this drug as a true broad-spectrum antiviral, but the “address label” can tailor it to go directly to particular organs. So if you have the flu, you would get lung-directed Draco; if you have a brain infection, it would go to your head.

Virologists face a long and arduous path if they wish to succeed in producing a wonder drug. And even success might bring unanticipated problems. That’s certainly the lesson from the story of broad-spectrum antibiotics. If you take penicillin for a salmonella infection, it will wipe out not just the salmonella but many other beneficial bacteria in your gut. Once the salmonella is gone, it may take weeks, months or even years for the microbial ecosystem to return to something resembling its former state. This disruption can, ironically, allow other pathogens to sneak in and establish themselves. We also depend on bacteria in our bodies to guide our immune systems on the proper path of development. A number of studies suggest that children who get a lot of antibiotics are more at risk of developing immune disorders such as allergies and asthma.

Our bodies are rife not just with bacteria but with viruses too. Even when we're perfectly healthy, we have trillions of viruses inside us. Scientists are only beginning to survey this viral ecology, but some suspect that it may actually be essential to our health. Many animals depend on viruses. Aphids, for example, need a virus that makes a toxin that prevents wasps from laying eggs inside their bodies. Scientists have found that infecting mice with lymphotrophic viruses protects them from developing diabetes. Other viruses attack cancer cells.

We may have such beneficial viruses inside our own bodies as well, waiting to be discovered. These viruses may not even infect our own cells but could instead be inside the bacteria that colonise us. Some species might keep the populations of their microbial hosts in check, like predators thinning a herd. Some viruses merge with bacteria rather than killing them, providing their hosts with useful genes for feeding or fighting off competitors. All of these microbe-infecting viruses may ultimately help us stay healthy.

It's conceivable that a broad-spectrum antiviral could devastate this complex, poorly understood biological jungle. As beneficial viruses disappeared, we might pay the price, developing diseases that the viruses used to keep at bay. Even Lingappa concedes that virus-killing could potentially go too far. "I don't think we want to kill all viruses," he says. "You only know about a virus when it does something bad. There's probably some virus out there doing something good."

Breaking the cycle

All viruses replicate in essentially the same way, and today's antiviral drugs aim to disrupt that process at different points. Here's how. CZ

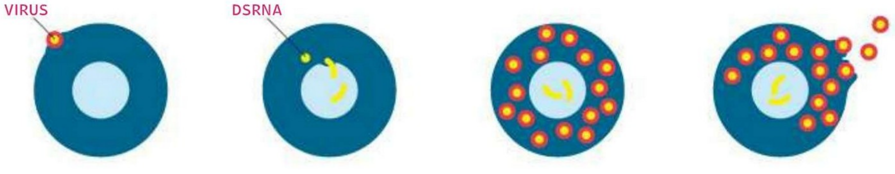
THE REPLICATION PROCESS

ENTER
Each type of virus has its own way of hijacking cells. With influenza, the virus shell contains proteins which bind to the surface of healthy cells and trigger them to open up.

REPLICATE
Once inside, the virus sheds its shell and its genes move to the cell's nucleus, hijacking the host to copy viral genes. They usually take the form of double-stranded RNA, or dsRNA.

NEUTRALISE CELL DEFENCE
Certain proteins in the cell will sense the dsRNA and trigger the production of antiviral interferons. But some viruses have evolved counterattacks against interferons.

MATURE
Viruses co-ordinate host proteins to become molecular machines, which then assemble new virus particles. Particles then bind to the cell's inner surface and open up an exit. It can now infect a new cell.

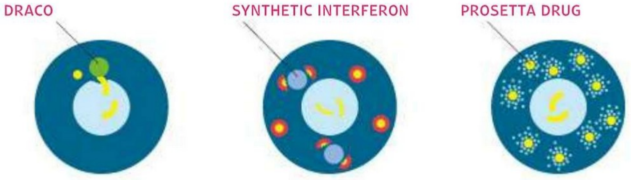


THE STRATEGIES

A. TRIGGER SUICIDE
An artificial molecule called Draco attaches itself to dsRNA, triggering the cell to commit suicide. The infected cells die before the viruses can mature.

B. AMP UP DEFENCES
Many viruses prevent cells from making its own interferons. By injecting us with synthetic interferons, doctors could trigger an antiviral response – whatever the virus.

C. INHIBIT MATURATION
Prosetta's molecules bind to the proteins that viruses need to create their shells, stopping the maturation process. The treatment is nontoxic to patients.



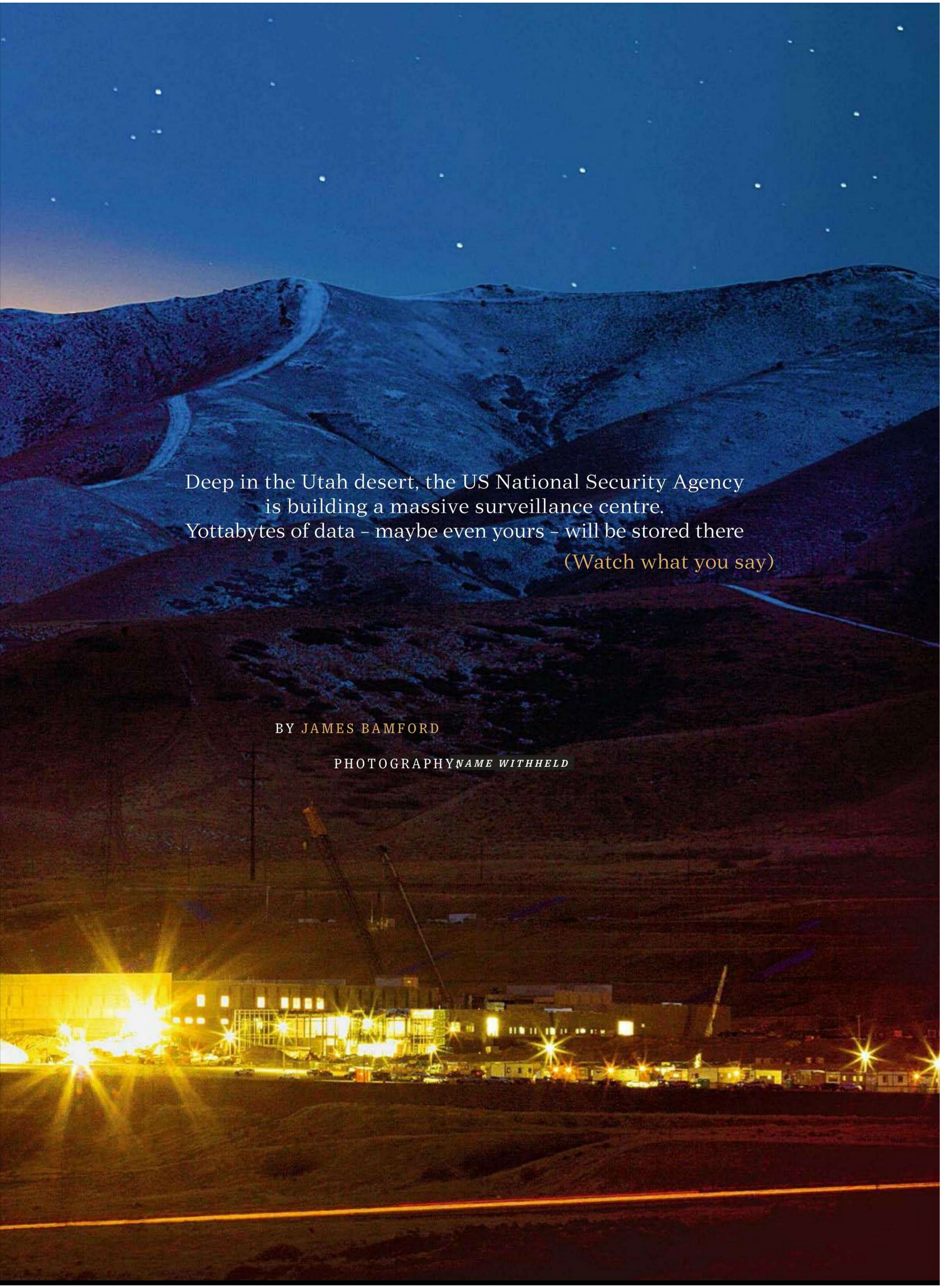
There's a book floating around the desks at Prosetta these days: *The Mould in Dr Florey's Coat*. It's about the discovery of penicillin, but the book's author, Eric Lax, has dredged up parts of the story that are often forgotten. Few people realise that Fleming abandoned research on penicillin not long after he discovered it. For more than a decade, while Fleming worked on vaccines and other projects, the potential of the drug went untapped. Fleming's work was all but forgotten until 1938, when the Oxford pathologist Howard Florey stumbled across his papers and decided to take up where Fleming had left off.

It took another five years for Florey to build a case powerful enough to persuade the pharmaceutical giant Eli Lilly to start making penicillin on an industrial scale. Florey, along with his collaborator Ernst Chain, shared the Nobel Prize with Fleming. But history tends to forget the 15 years of inaction and struggle that separated the iconic discovery of penicillin from its mass production.

Lingappa considers the book a necessary education for anyone who would dare to make the penicillin of viruses. "Everyone remembers Fleming," he says. "He tried and failed, and it took Florey to come a decade later and ask, whatever happened to that stuff Fleming was working on?" If the true history of penicillin can be any guide for scientists working on antivirals, it teaches them to hunker down and get ready to work for years – to prepare for disappointment and obscurity on the way to finding a drug that works not just in a dish of cells or a mouse but in a human being. The scientists who are working on antivirals today may not be the ones who find that drug. But if they do, future generations may some day tell the story of Vishwanath Lingappa's rabies or of Todd Rider and Draco. W

Carl Zimmer wrote A Planet of Viruses *(University of Chicago Press) and* Science Ink: Tattoos of the Science Obsessed *(Sterling)*

THE BLACK BOX



Deep in the Utah desert, the US National Security Agency
is building a massive surveillance centre.
Yottabytes of data – maybe even yours – will be stored there

(Watch what you say)

BY JAMES BAMFORD

PHOTOGRAPHY *NAME WITHHELD*

The spring air in the small, sand-dusted town has a soft haze to it, and green-grey sagebrush rustles in the breeze. Bluffdale sits in a valley in the shadow of Utah's Wasatch Range to the east and the Oquirrh Mountains to the west. It's the heart of Mormon country, where religious pioneers arrived more than 160 years ago. They came to escape the world, to understand the mysterious words sent from their god as revealed on golden plates, and to practise what has become known as "the principle", marriage to multiple wives.

But new pioneers have quietly begun moving into the area, secretive outsiders who keep to themselves. They too are focused on deciphering cryptic messages that only they have the power to understand. Just off Beef Hollow Road, less than 2km from brethren headquarters, thousands of hard-hatted builders are laying the groundwork for the newcomers' own temple and archive, a complex so large that it necessitated expanding the town's boundaries. Once built, it will be more than five times the size of the US Capitol.

Rather than Bibles and worshippers, this temple will be filled with servers, computer intelligence experts and armed guards. These newcomers will be capturing, storing and analysing vast quantities of words and images hurtling through the world's telecommunications networks. In the town of Bluffdale, Big Love and Big Brother have become uneasy neighbours.

The blandly named Utah Data Center is being built for the US National Security Agency (NSA). A project of immense secrecy, it is the final piece in a complex puzzle assembled over the past decade. Its purpose: to intercept, decipher, analyse and store vast amounts of the world's communications from satellites and underground and undersea cables of international, foreign and domestic networks. The heavily fortified $2 billion centre should be operational in September 2013. Stored in near-bottomless databases will be all forms of communication, including private emails, mobile phone calls and Google searches, as well as personal data trails – travel itineraries, purchases and other digital "pocket litter". It is the realisation of the "total information awareness" programme created by the Bush administration – which was killed by Congress in 2003 after an outcry over its potential for invading privacy.

But "this is more than just a data centre", says one senior intelligence official who until recently was involved with the programme. The mammoth Bluffdale centre will have another important and far more secret role. It is also critical, he says, for breaking codes, which is crucial because much of the data that the centre will handle – financial information, business deals, foreign military and diplomatic secrets, legal documents, confidential personal communications – will be heavily encrypted. According to another top official also involved, the NSA made a breakthrough several years ago in cryptanalysis, or breaking complex encryption systems used not only by governments around the world but also average computer users. The upshot, says this official, is that "everybody's a target; everybody with communication is a target."

For the NSA, with tens of billions of dollars in post-9/11 budget awards, the cryptanalysis breakthrough came at a time of explosive growth in size and power. Established as an arm of the US Department of Defense (DoD) following Pearl Harbor, the NSA suffered a series of humiliations in the post-Cold War years. Caught off guard by the first World Trade Center bombing, the blowing up of US embassies in East Africa, the attack on the USS Cole in Yemen and 9/11, the agency's reason to exist was in question. In response, the NSA has quietly been reborn. And although there is little indication that its effectiveness has improved – after all, it missed the attempted attacks by the underwear bomber on a flight to Detroit in 2009, and the car bomber in Times Square in 2010 – there is no doubt that it has transformed itself into the largest, most covert and potentially most intrusive intelligence agency ever created.

In the process – and for the first time since Watergate – the NSA has turned its surveillance apparatus on the US and its citizens. It has established listening posts throughout the nation to collect and sift through billions of emails and phone calls, whether they originate within the country or overseas. It has created a supercomputer to look for patterns and unscramble codes. Finally, the agency has begun building a place to store everything captured in its electronic net. And, it's all being done in secret.

Freezing fog blanketed Salt Lake City on the morning of January 6, 2011, mixing with heavy grey smog. At the city's international airport, many inbound flights were delayed or diverted and outbound jets were grounded. But among those making it through was a figure whose grey suit and tie made him almost blend into the background. He was tall and thin, with dark caterpillar eyebrows beneath a shock of matching hair. Accompanied by bodyguards, the man was NSA deputy director Chris Inglis, the agency's highest-ranking civilian who ran its worldwide day-to-day operations.

Inglis arrived in Bluffdale at the site of the future data centre, a flat, unpaved runway on a little-used part of Camp Williams, a National Guard training site. There, in a tent set up for the occasion, Inglis joined Harvey Davis, the agency's associate director for installations and logistics, and Utah senator Orrin Hatch, along with a few generals and politicians in a surreal ceremony. Standing in an odd wooden sandbox and holding gold-painted shovels, they jabbed awkwardly at the sand and thus officially broke ground on what the local media had dubbed "the spy centre". Hoping for some details on what was to be built, reporters turned to one of the guests, Lane Beattie of the Salt Lake Chamber of Commerce. Did he have any idea of the purpose behind the new facility? "Absolutely not," he said with a half laugh. "Nor do I want them spying on me."

Inglis simply engaged in double-talk, emphasising the least threatening aspect of the centre: “It’s a state-of-the-art facility designed to support the intelligence community in its mission to, in turn, enable and protect the nation’s cybersecurity.” Cybersecurity will certainly be among the areas focused on in Bluffdale – what and how it is collected, and what is done with the material, are more important issues. Battling hackers makes for a nice cover – who could be against it? Then the reporters turned to Hatch, who proudly described the centre as “a great tribute to Utah”.

This was supposedly the official ground-breaking for the nation’s largest cybersecurity project, yet no one from the Department of Homeland Security, the agency responsible for protecting civilian networks from cyberattack, spoke at it. In fact, the official who’d originally introduced the data centre, at a press conference in Salt Lake City in October 2009, had nothing to do with cybersecurity. It was Glenn Gaffney, deputy director of national intelligence for collection, a career CIA man. As head of collection for the intelligence community, he managed the country’s human and electronic spies.

Within days, the gold shovels would be gone and Inglis and the generals would be replaced by some 10,000 builders. The plans for the centre show an extensive security system: an elaborate $10 million (£6m) anti-terrorism protection programme, including a fence designed to stop a heavy vehicle travelling 80kph, closed-circuit cameras, a biometric identification system, a vehicle-inspection facility and a visitor-control centre. Inside, the facility will consist of four 2,300-square-metre halls filled with servers, complete with raised floor space for cables and storage. In addition, there will be more than 83,600 square metres for technical support and administration. The entire site will be self-sustaining, with fuel tanks large enough to power the backup generators for three days in an emergency, water storage with the capability of pumping 6.4 million litres of liquid per day, as well as a sewage system and air-conditioning system to keep all those servers cool. Electricity will come from the centre’s own substation built by Rocky Mountain Power to satisfy the 65-megawatt power demand. Such a mammoth amount of energy comes with a mammoth price tag – about $40 million (£25 million) a year, according to one estimate.

THE BLANDLY NAMED UTAH DATA CENTER IS BEING BUILT FOR THE NATIONAL SECURITY AGENCY. ITS PURPOSE: TO DECIPHER, ANALYSE AND STORE VAST AMOUNTS OF COMMUNICATIONS

Given the facility’s scale and the fact that a terabyte of data can now be stored on a flash drive the size of your little finger, the amount of information that could be housed in Bluffdale is staggering. But so is the exponential growth in the amount of intelligence data being produced every day by the sensors of the intelligence agencies. As a result of this “expanding array of theatre airborne and other sensor networks”, as a 2007 Department of Defense report puts it, the Pentagon is trying to expand its worldwide communications network, known as the Global Information Grid, to handle yottabytes (10^{24} bytes) of data. (A yottabyte is a septillion bytes – so large that no one has yet coined a term for the next higher magnitude.) It needs that capacity because, according to a report by Cisco, global internet traffic will quadruple from 2010 to 2015, reaching 966 exabytes per year. (A million exabytes equal a yottabyte.) Eric Schmidt, Google’s former CEO, once estimated that all human knowledge created from the dawn of man to 2003 totalled five exabytes. And the flow shows no sign of slowing. In 2011 more than two billion of the world’s 6.9 billion people were connected to the internet. By 2015, market research firm IDC estimates, there will be 2.7 billion users. Thus, the NSA’s need for a 93,000-square-metre data storehouse. Should the agency ever fill the Utah centre with a yottabyte of information, it would be equal to about 500 quintillion (500,000,000,000,000,000,000) pages of text.

The data stored in Bluffdale will go far beyond the world’s billions of public web pages. The NSA is more interested in the invisible web, also known as the deep web or deepnet – data beyond the reach of the public. This includes password-protected data, US and foreign government communications, and non-commercial file-sharing between trusted peers. “The deep web contains government reports, databases and other sources of information of high value to DoD and the intelligence community,” according to a 2010 Defense Science Board report. “Tools are needed to find and index data in the deep web... Stealing the classified secrets of a potential adversary is where the [intelligence] community is most comfortable.”

With its new Utah Data Center, the NSA will at last have the capability to store, and rummage through, all those stolen secrets. The question, of course, is how the agency defines who is, and who is not, “a potential adversary”.

Before yottabytes of data can begin piling up inside the servers of the NSA’s new centre, they must be collected. To achieve that more efficiently, the agency has installed secret electronic-monitoring rooms in major US telecom facilities. These are where the agency taps into the US communications networks, a practice that came to light during the Bush years but was never acknowledged by the agency. The broad outlines of the so-called warrantless-wiretapping programme have long been exposed – how the NSA secretly and illegally bypassed the Foreign Intelligence Surveillance Court, which was supposed to oversee and authorise highly targeted domestic eavesdropping; how the programme allowed monitoring of millions of American phone calls and email. In the wake of the programme’s exposure, Congress passed the FISA Amendments Act of 2008, which largely made the practices legal. Telecoms that had agreed to participate in the illegal activity were granted immunity from prosecution and lawsuits. What hasn’t been revealed until now, however, was the size of this domestic spying programme.

For the first time, a former NSA official has gone on the record to describe the programme, codenamed Stellar Wind, in detail. William Binney was a senior crypto-mathematician responsible for automating the agency’s worldwide listening network. A tall man with dark, determined eyes behind thick-rimmed glasses, the 68-year-old spent nearly four decades breaking codes and finding new ways to channel billions of private phone calls and email messages from around the world into the NSA’s bulging databases. As chief and one of the two cofounders of the agency’s Signals Intelligence Automation Research Center, Binney and his team designed much of the infrastructure that’s still probably in use.

He explains that the agency could have installed its gear at the nation’s cable landing stations – the two dozen or so sites where fibre-optic cables come ashore. If it had, the NSA could have limited its eavesdropping to international communications, which at that time was all that was allowed under US law. Instead it put wiretapping rooms at key junctions throughout the country, thus gaining access to most of the domestic traffic. The network of intercept stations, or “switches”, goes far beyond the room in an AT&T building in San Francisco exposed by a whistleblower in 2006. "I think there's ten to 20 of them," Binney says. "Not just San Francisco; they have them in the middle of the country and on the East Coast."

Listening in doesn't stop at the telecom switches. To capture satellite communications, the agency also monitors AT&T's powerful earth stations, satellite receivers in locations that include Roaring Creek and Salt Creek. Tucked away in rural Pennsylvania, Roaring Creek's three 32-metre dishes handle much of the country's communications to and from Europe and the Middle East. And on a remote stretch in Arbuckle, California, three similar dishes at the company's Salt Creek station service the Pacific Rim and Asia.

Binney left the NSA in late 2001, shortly after the agency launched its warrantless-wiretapping programme. "They violated the [US] Constitution setting it up," he says. "But they didn't care. They were going to do it, and they were going to crucify anyone who stood in the way. When they started violating the Constitution, I couldn't stay." Binney says Stellar Wind was larger than has been disclosed and included listening to domestic phone calls as well as inspecting domestic email. At the outset the programme recorded 320 million calls a day, he says – about 73 to 80 per cent of the total volume of the agency's worldwide intercepts.

The haul only grew. According to Binney – who has kept close contact with agency employees until a few years ago – the taps in the secret rooms dotting the country are powered by software programs that conduct "deep packet inspection", examining internet traffic as it passes through the ten-gigabit-per-second cables at the speed of light.

The software, created by a company called Narus that's now part of Boeing, is controlled from NSA headquarters at Fort Meade in Maryland and searches US sources for addresses, locations, countries and phone numbers, as well as watch-listed names, keywords and phrases in emails. Any communication that arouses suspicion, especially those to or from the million or so people on agency watch lists, is recorded and transmitted to the NSA. The scope expands from there, Binney says. Once a name is entered into the Narus database, all communications to and from that person are routed to the NSA's recorders. "If your number's in there? Routed and gets recorded." And when Bluffdale is completed, whatever is collected will be routed there.

ANY COMMUNICATION THAT AROUSES SUSPICION, ESPECIALLY THOSE FROM THE MILLION OR SO PEOPLE ON WATCH LISTS, IS RECORDED AND TRANSMITTED TO THE NSA

According to Binney, one of the deepest secrets of the Stellar Wind programme – again, never confirmed until now – was that the NSA gained warrantless access to AT&T's domestic and international billing records. As of 2007, AT&T had more than 2.8 trillion records in a database at its Florham Park, New Jersey, complex. Verizon was also part of the programme. "That multiplies the call rate by at least a factor of five," Binney says. "So you're over a billion and a half calls a day." (Verizon and AT&T said they would not comment on matters of national security.)

After he left the NSA, Binney suggested a system for monitoring people's communications according to how closely they are connected to a target. The further away from the target – say just an acquaintance of a friend of the target – the less the surveillance. But the agency rejected the idea, and, given the massive new storage facility in Utah, Binney suspects that it now simply collects everything. He says: "They're storing everything they gather."

Once communications are stored, the datamining begins. "You can watch everybody all the time with datamining," Binney says. Everything a person does is charted on a graph, "financial transactions or travel or anything", he says. Thus the NSA is able to paint a detailed picture of someone's life. The NSA can also eavesdrop on phone calls directly and in real time. According to Adrienne Kinne, who worked before and after 9/11 as a voice interceptor at the NSA facility in Georgia, in the wake of the World Trade Center attacks "basically all rules were thrown out the window, and they would use any excuse to justify a waiver to spy on Americans". Even journalists calling home from overseas were included. "A lot of time you could tell they were calling their families," she says. "Intimate, personal conversations." Kinne found eavesdropping on innocent citizens distressing. "It's like finding somebody's diary," she says.

But there is reason for everyone to be distressed about the practice. Once the door is open for the government to spy on US citizens, there are temptations to abuse that power for political purposes, as when Richard Nixon eavesdropped on his political enemies during Watergate and ordered the NSA to spy on anti-war protesters. Those and other abuses prompted Congress to enact prohibitions in the mid-1970s against domestic spying.

Before he left the NSA, Binney tried to persuade officials to create a more targeted system that could be authorised by a court. At the time, the agency had 72 hours to obtain a legal warrant; Binney devised a method to computerise the system. But such a system would have required close co-ordination with the courts, and NSA officials weren't interested, Binney says. Asked how many communications – "transactions", in NSA's lingo – the agency has intercepted since 9/11, Binney estimates "between 15 and 20 trillion over 11 years".

Binney hoped that Barack Obama's new administration might be open to addressing constitutional concerns. He and another former senior NSA analyst, J Kirk Wiebe, tried to explain an automated warrant-approval system to the Department of Justice's inspector general. They were given the brush-off. "They said, oh, OK, we can't comment," Binney says. Sitting in a restaurant not far from NSA headquarters, the place where he spent nearly 40 years of his life, Binney held his thumb and forefinger close together. "We are, like, that far from a turnkey totalitarian state," he says.

There is still one technology preventing untrammelled government access to private digital data: strong encryption. Anyone – from terrorists and weapons dealers to corporations, financial institutions and ordinary email senders – can use it to seal their messages, plans, photos and documents in hardened data shells. For years, one of the hardest shells has been the Advanced Encryption Standard (AES), one of several algorithms used by much of the world to encrypt data. Available in three different strengths – 128 bits, 192 bits and 256 bits – it's incorporated in most commercial email programs and web browsers and is considered so strong that the NSA has even approved its use for top-secret US government communications. Most experts say that a so-called brute-force computer attack on the algorithm – trying one combination after another to unlock the encryption – would likely take longer than the age of the universe. For a 128-bit cipher, the number of trial-and-error attempts would be 340 undecillion (10^{36}).

Breaking into those complex mathematical shells like the AES is one of the key reasons for the construction going on in

SOURCE: US ARMY CORPS OF ENGINEERS CONCEPTUAL SITE PLAN

Bluffdale. That kind of cryptanalysis requires two major ingredients: super-fast computers to conduct brute-force attacks on encrypted messages and a massive number of those messages for the computers to analyse. The more messages from a given target, the more likely it is for the computers to detect telltale patterns, and Bluffdale will be able to hold a great many messages. “We questioned it one time,” says another source, a senior intelligence manager who was also involved with the planning. “Why were we building this NSA facility? And, boy, they rolled out all the old guys – the crypto guys.” According to the official, these experts told then-director of national intelligence Dennis Blair, “You’ve got to build this thing because we just don’t have the capability of doing the code-breaking.” It was a candid admission. In the long war between the code breakers and the code makers – the tens of thousands of cryptographers in the worldwide computer-security industry – the code breakers were admitting defeat.

So the agency had one major ingredient – a massive data-storage facility – under way. Meanwhile, across the country in Tennessee, the US government was working in utmost secrecy on the other vital element: the most powerful computer the world has ever known. The plan was launched in 2004 as a modern-day Manhattan Project. Dubbed the High Productivity Computing Systems programme, its goal was to advance computer speed a thousandfold, creating a machine that could execute a quadrillion (10^{15}) operations a second, known as a petaflop – the computer equivalent of breaking the land speed record. And as with the Manhattan Project, the venue chosen for the supercomputing programme was the town of Oak Ridge in eastern Tennessee, a rural area where sharp ridges give way to low, scattered hills, and the southwestward-flowing Clinch River bends sharply to the southeast. About 40km from Knoxville, it is the “secret city” where uranium-235 was extracted for the first atomic bomb. A sign near the exit said: “What you see here, what you do here, what you hear here, when you leave here, let it stay here.” Today, not far from where that sign stood, Oak Ridge is home to the Department of Energy’s Oak Ridge National Laboratory, and it’s engaged in a new secret war.

THE UTAH DATA CENTER

WHEN CONSTRUCTION IS COMPLETED IN 2013, THE HEAVILY FORTIFIED $2 BILLION FACILITY IN BLUFFDALE WILL ENCOMPASS 92,000 SQUARE METRES.

1. VISITOR-CONTROL CENTRE
A $10 million facility for ensuring that only cleared personnel gain access.

2. ADMINISTRATION CENTRE
Designated space for technical support and administrative personnel.

3. DATA HALLS
Four 2,300-metre-square facilities house rows and rows of servers.

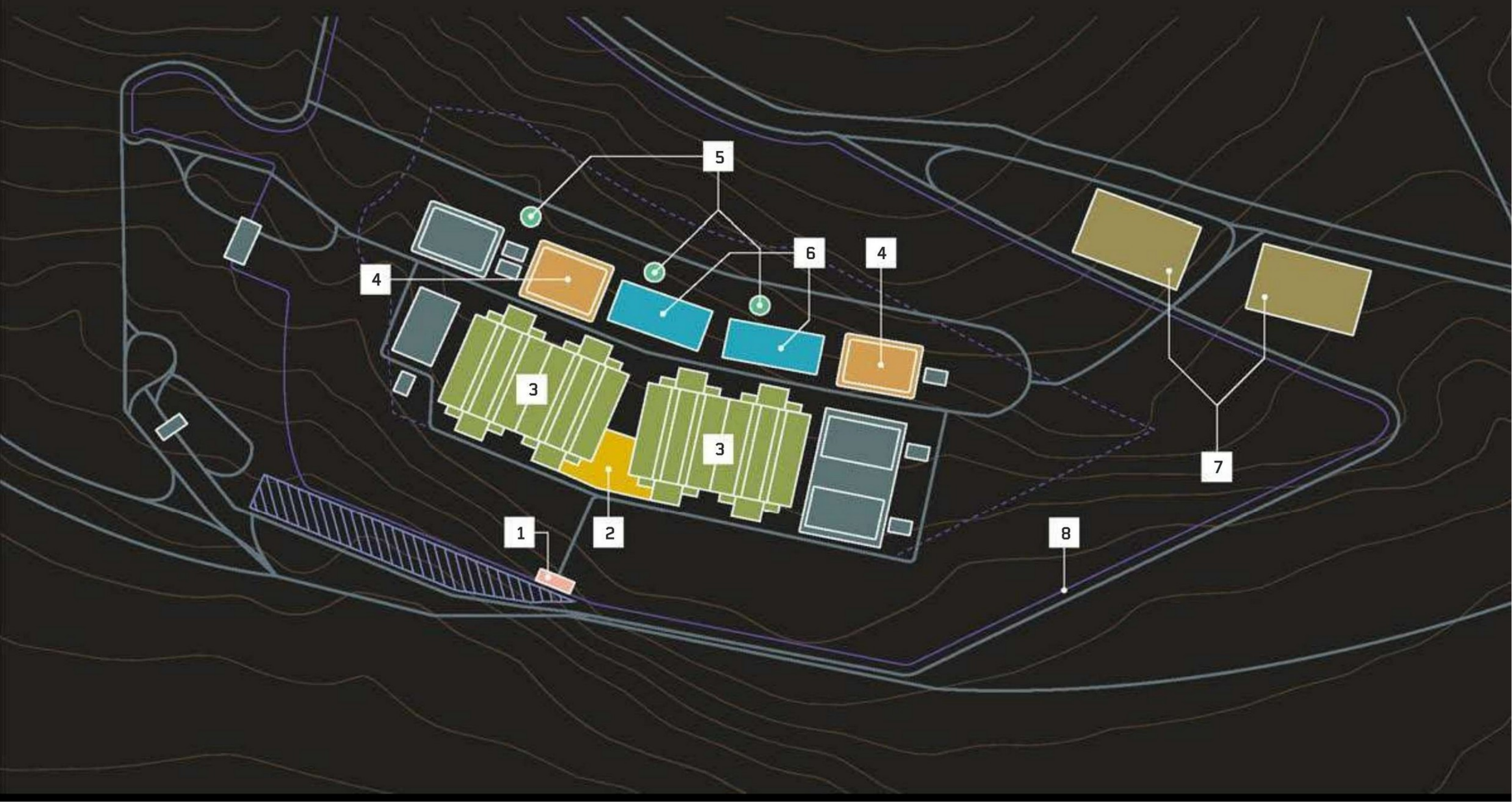
4. FUEL AND BACKUP GENERATORS
These can power the centre independently for at least three days.

5. WATER STORAGE AND PUMPING
Able to pump 6.4 million litres of liquid per day, to cool the servers.

6. CHILLER PLANT
Where the cooling equipment to keep servers from overheating is kept.

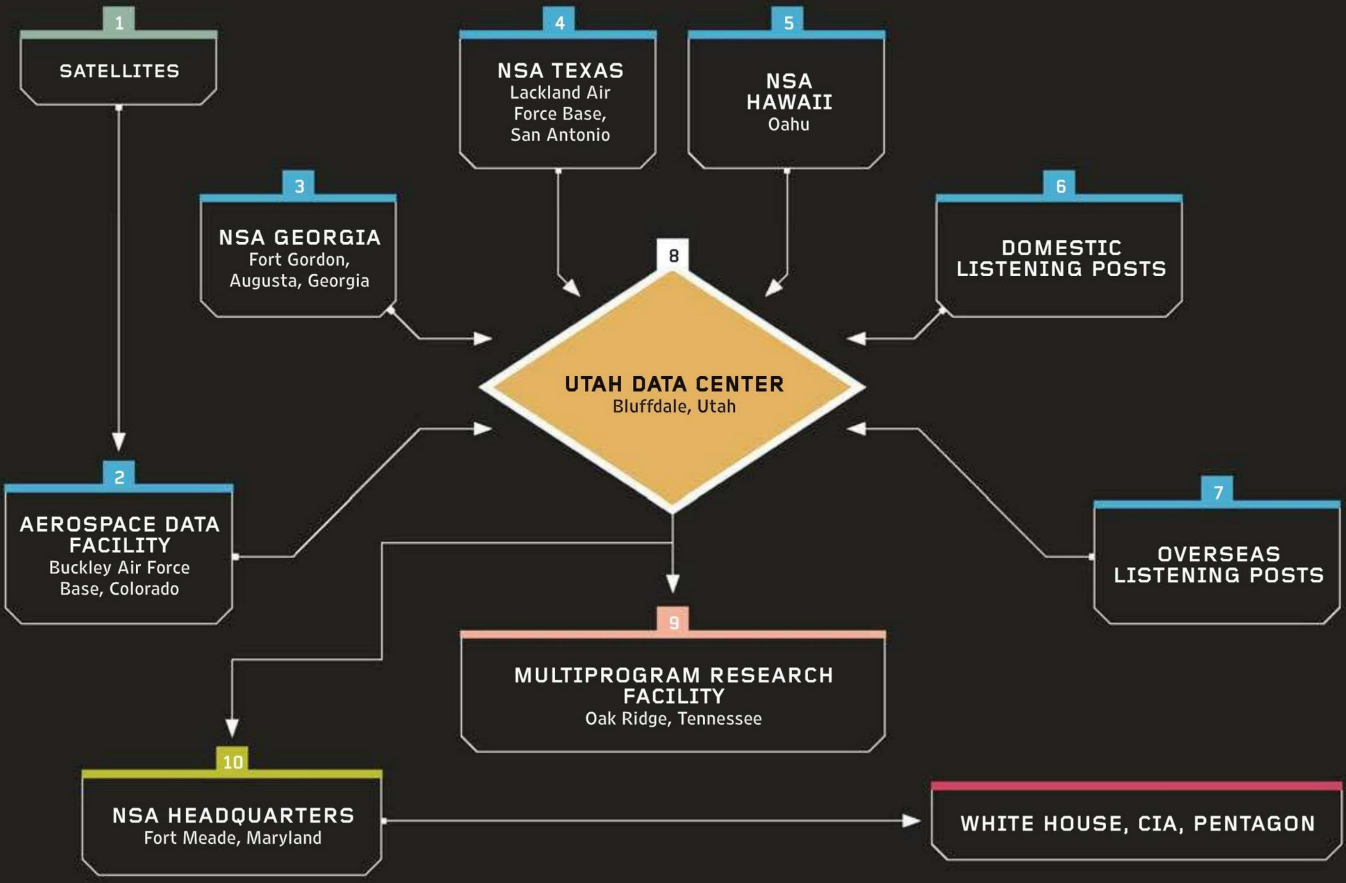
7. POWER SUBSTATION
An electrical substation to meet the centre’s estimated 65MW demand.

8. SECURITY MEASURES
Video surveillance, intrusion detection and more will cost $10 million.



THE NSA'S SPY NETWORK

ONCE IT'S OPERATIONAL, THE UTAH DATA CENTER WILL BECOME, IN EFFECT, THE NSA'S CLOUD. THE MASSES OF COLLECTED DATA, FED FROM ACROSS THE NETWORK, WILL THEN BE ACCESSIBLE TO THE NSA'S CODE BREAKERS, DATA-MINERS, CHINA ANALYSTS, COUNTERTERRORISM SPECIALISTS AND OTHERS WORKING AT ITS FORT MEADE HEADQUARTERS AND AROUND THE WORLD. HERE'S HOW THE DATA CENTRE APPEARS TO FIT INTO THE NSA'S GLOBAL PUZZLE. **JB**



1. GEOSTATIONARY MONITORING SATELLITES

Four satellites monitor frequencies carrying everything from walkie-talkies in Libya to radar systems in North Korea. Onboard software acts as the first-stage filter.

2. AEROSPACE DATA FACILITY, BUCKLEY AIR FORCE BASE

Intelligence is relayed to this facility outside Denver. About 850 NSA employees track the satellites, transmit target information and download the intelligence haul.

3. NSA GEORGIA, FORT GORDON, AUGUSTA, GA

Focuses on intercepts from Europe, the Middle East, and North Africa. Codenamed "Sweet Tea", the facility is being massively expanded, due for completion in 2013.

4. NSA TEXAS, LACKLAND AIR FORCE BASE

Focuses on intelligence intercepts from Latin America and, since 9/11, the Middle East and Europe. Some 2,000 workers staff the operation.

5. NSA HAWAII, OAHU

Focuses on intercepts from Asia. Built to house a WWII aircraft assembly plant, its 23,000m^2 bunker is nicknamed "The Hole". A 21,000m^2 above-ground facility was recently added.

6. DOMESTIC LISTENING POSTS

After 9/11, the NSA installed taps in US telecom "switches", gaining access to domestic traffic. An ex-NSA official says there are ten to 20 such installations.

7. OVERSEAS LISTENING POSTS

According to one source, the NSA has installed taps on at least a dozen overseas communications links, each capable of eavesdropping on any information passing by.

8. UTAH DATA CENTER, BLUFFDALE, UTAH

At 92,000m^2, this $2 billion digital storage facility outside Salt Lake City will be the centerpiece of the NSA's cloud-based data strategy and essential to decrypting documents.

9. MULTIPROGRAM RESEARCH FACILITY, TN

Some 300 scientists and computer engineers with top security clearance toil here, building the world's fastest supercomputers and working on secret cryptanalytic applications.

10. NSA HEADQUARTERS, FORT MEADE, MD

Where material stored at Bluffdale will be analysed for reports and recommendations that are sent to policymakers. The NSA is also building an $896m supercomputer here.

In 2004, as part of the supercomputing programme, the Department of Energy established its Oak Ridge Leadership Computing Facility for multiple agencies to join forces on the project. But in reality there would be two tracks, one unclassified, in which all of the scientific work would be public, and another top secret, in which the NSA could pursue its own computer covertly. "For our purposes, they had to create a separate facility," says a former senior NSA computer expert who worked on the project and is still associated with the agency. (He is one of three sources who described the programme.) It was an expensive undertaking.

Known as the Multiprogram Research Facility, or Building 5300, the $41 million, five-storey, 20,000m^2 structure was built on a plot of land on the lab's East Campus and completed in 2006. Inside, 318 scientists, computer engineers and other staff work in secret on the cryptanalytic applications of high-speed computing and other classified projects. The centre was named in honour of George R Cotter, the NSA's now-retired chief scientist and head of its information technology programme. Not that you'd know it. "There's no sign on the door," says the ex-NSA computer expert.

At the DOE's unclassified centre at Oak Ridge the team had its Cray XT4 supercomputer upgraded to a warehouse-sized XT5. Named Jaguar for its speed, it clocked in at 1.75 petaflops and was the world's fastest computer in 2009.

Meanwhile, over in Building 5300, the NSA succeeded in building an even faster supercomputer. "They made a big breakthrough," says another former senior intelligence official, who helped oversee the programme. The NSA's machine was probably similar to the unclassified Jaguar, but it was much faster out of the gate, modified specifically for cryptanalysis and targeted against one or more specific algorithms, like the AES. They were moving from the R&D phase to actually attacking extremely difficult encryption systems. The codebreaking effort was up and running.

'A LOT OF FOREIGN GOVERNMENT STUFF WE'VE NEVER BEEN ABLE TO BREAK IS 128[-BIT] OR LESS. BREAK THAT AND YOU'LL FIND OUT A LOT MORE OF WHAT YOU DIDN'T KNOW'

The agency pulled the shade down on the project, says the former official. "Only the chairman, vice chairman and the two staff directors of each intelligence committee were told," he says. "They were thinking this was going to give them the ability to crack current public encryption."

In addition to giving the NSA access to a tremendous amount of Americans' personal data, such an advance would also open a window on a trove of foreign secrets. Whereas today most sensitive communications use the strongest encryption, much of the older data stored by the NSA, including a great deal of what will be transferred to Bluffdale once the centre is complete, is encrypted with more vulnerable ciphers. "Remember," says the former intelligence official, "a lot of foreign government stuff we've never been able to break is 128[-bit] or less. Break all that and you'll find out a lot more of what you didn't know – stuff we've already stored – so there's an enormous amount of information still in there."

That, he notes, is where the value of Bluffdale and its mountains of long-stored data will come in. What can't be broken today may be broken tomorrow. "Then you can see what they were saying in the past," he says. "By extrapolating the way they did business, it gives us an indication of how they may do things now." The danger, the former official says, is that it's not only foreign government information that is locked in weaker algorithms; it's also a great deal of personal domestic communications, such as Americans' email intercepted by the NSA in the past decade.

But first the supercomputer must break the encryption, and to do that, speed is everything. The faster the computer, the faster it can break codes. The Data Encryption Standard, the 56-bit predecessor to the AES, debuted in 1976 and lasted about 25 years. The AES made its first appearance in 2001 and is expected to remain strong and durable for at least a decade. But if the NSA has secretly built a computer that is considerably faster than machines in the unclassified arena, then the agency has a chance of breaking the AES in a much shorter time. And with Bluffdale in operation, the NSA will have the luxury of storing an ever-expanding archive of intercepts until that breakthrough comes along.

But despite its progress, the agency has not finished building at Oak Ridge, nor is it satisfied with breaking the petaflop barrier. Its next goal is to reach exaflop speed, one quintillion (10^{18}) operations a second, and eventually zettaflop (10^{21}) and yottaflop.

These goals have considerable support in Congress. Last November a bipartisan group of 24 senators sent a letter to President Obama urging him to approve continued funding through 2013 for the Department of Energy's exascale computing initiative (the NSA's budget requests are classified). They cited the necessity to keep up with and surpass China and Japan. "The race is on to develop exascale computing capabilities," the senators noted. By late 2011 the Jaguar (now with a peak speed of 2.33 petaflops) ranked third behind Japan's "K Computer", with 10.51 petaflops, and the Chinese Tianhe-1A system, with 2.57 petaflops.

But the real competition will take place in the classified realm. To secretly develop the new exaflop (or higher) machine by 2018, the NSA has proposed constructing two connecting buildings, totalling 24,100m^2, near its current facility on the East Campus of Oak Ridge. Called the Multiprogram Computational Data Center, the buildings will be low and wide like giant warehouses, a design necessary for the dozens of computer cabinets that will compose an exaflop-scale machine, possibly arranged in a cluster to minimise the distance between circuits. According to a presentation delivered to DoE employees in 2009, it will be an "unassuming facility with limited view from roads", in keeping with the NSA secrecy. And it will have an extraordinary appetite for electricity, using about 200 megawatts, enough to power 200,000 homes. In the meantime Cray is working on the next step for the NSA, funded in part by a $250 million contract with the Defense Advanced Research Projects Agency. It's a massively parallel supercomputer called Cascade, a prototype of which is due at the end of 2012. Its development will run alongside the unclassified effort for the DoE and other partner agencies. That project, due in 2013, will upgrade the JaguarXT5 into an XK6, codenamed Titan, upping its speed to ten to 20 petaflops.

Yottabytes and exaflops, septillions and undecillions – the race for computing speed and data storage goes on. In his 1941 story *The Library of Babel*, Jorge Luis Borges imagined a collection of information where the entire world's knowledge is stored but barely a single word is understood. In Bluffdale the NSA is constructing a library on a scale that even Borges might not have contemplated. And to hear the masters of the agency tell it, it's only a matter of time until every word is illuminated.

James Bamford is author of The Shadow Factory: The Ultra-Secret NSA from 9/11 to the Eavesdropping on America *(Anchor Books)*

THE ESSENTIAL BIANNUAL GUIDE TO MEN'S STYLE
GQ Style
SPRING-SUMMER ISSUE
ON SALE 15 MARCH
photography by JACK PIERSON

TEST

LAB RESULTS
THIS MONTH: 05.12

- CHEFS' SAUCEPANS
- ELECTRIC BIKES
- ULTRABOOKS

EDITED BY
JIM HILL

ELECTRIC RIDERS

We go for a spin on the latest e-bikes

PHOTOGRAPHY: SUN LEE

THE HEAT IS ON

There's a trend for TV chefs to launch cookware. So how do they pan out?

JAMIE OLIVER
20CM SAUCEPAN BY TEFAL

This non-stick pan is suitable for induction and gas hobs, and claims to be durable enough to be used with metal utensils. It features a copper ring and heart in the base to ensure even cooking, and was very easy to clean – our testing chef Andre Dupin was impressed by how "stuck-on tomato sauce just slid off". It's also dishwasher-safe.

WIRED Effective non-stick cooking surface

TIRED No second handle

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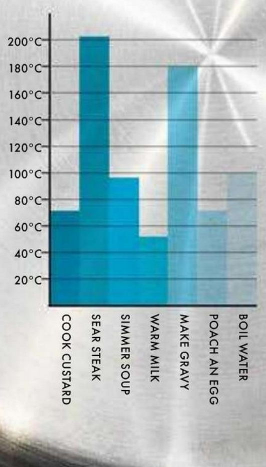
£42, homeandcook.co.uk

OPTIMUM TEMPERATURES



HOW WE RATE

1> A complete failure in every way
2> Barely functional – don't buy it
3> Serious flaws – buy with caution
4> Downsides outweigh upsides
5> Recommended with reservations
6> A solid product with some issues
7> Very good, but not quite great
8> Excellent with only a few niggles
9> Nearly flawless – buy it now
10> Metaphysical product perfection

SECRET INGREDIENTS

	JAMIE OLIVER	JAMES MARTIN	RAYMOND BLANC	GINO D'ACAMPO	MICHEL ROUX
TIME TAKEN TO BOIL 500ML OF WATER (SEC)	174 GAS/ 85 IND	173 GAS/ 104 IND	148 GAS/ N/A IND	158 GAS/ N/A IND	217 GAS/ 82 IND
MATERIAL	STAINLESS-STEEL BODY WITH STEEL LID	STAINLESS-STEEL BODY WITH VENTED GLASS LID	ANODISED ALUMINIUM WITH VENTED GLASS LID	ANODISED ALUMINIUM, STAINLESS-STEEL HANDLE, GLASS LID	TRI-PLY STAINLESS-STEEL BODY AND LID
OVEN SAFE	TO 260°C	TO 220°C	TO 180°C	NO	TO 450°C
WEIGHT	1,486 GRAMS	1,742 GRAMS	1,576 GRAMS	1,456 GRAMS	1,092 GRAMS
SUITABLE FOR INDUCTION	YES	YES	NO	NO	YES

JAMES MARTIN 20CM SAUCEPAN BY STELLAR

Suitable for gas and induction hobs, the thick, hot-forged base of this pan distributes heat quickly. The pan's outer layer is made from polished stainless steel, so it's easy to clean as well as eye-catching. Our chef found the sculpted handle gave the most secure grip; the "helper handle" makes moving a full pan less spill-prone.

WIRED Useful second handle for carrying

TIRED The glass lid is potentially vulnerable

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£43, stellarcookware.co.uk

HOW WE TESTED

We gave five TV chef-endorsed 20cm saucepans to Andre Dupin, head chef at L'atelier des Chefs cookery school (atelierdeschefs.co.uk). We timed how long it took to boil cold water on gas and induction hobs, and assessed design, heat distribution, and cleaning.

PHOTOGRAPHY: SUN LEE; DAVE LIDWELL. WORDS: EMILY PECK

RAYMOND BLANC PROFESSIONAL 20CM SAUCEPAN

With its riveted handle and lid, this deep saucepan looks serious and stylish. "Although you can't use it on an induction hob, [Blanc's] pan does the job it needs to do," says Dupin. The non-stick coating is effective, but cleaning it requires a gentle touch – so no scouring with wire-wool as you would a stainless-steel pan.

WIRED Quickest to boil up on a gas hob

TIRED You can't cook by induction

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£64, raymondblancbyanolon.com

GINO D'ACAMPO 20CM SAUCEPAN

This 20cm design comes as part of a set of three – with 18cm and 16cm models included – and features tempered glass lids with steam vents which prevent the pan from boiling over. Dupin noted that its aluminium body could have done with a little more weight to it, "but that doesn't mean this isn't a good saucepan – and it's reasonably priced for a set of three." This pan can't be used on induction hobs, and Dupin would not recommend putting it in the dishwasher as it could spoil the anodised finish.

WIRED Set of three represents good value

TIRED Bland design; feels insubstantial

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£55, tesco.com

MICHEL ROUX 20CM SAUCEPAN BY GREENPAN

This beautifully finished pan has an all-round pouring rim to minimise spillage. Made from tri-ply stainless steel, it has a vented lid and a Thermalon ROCKS coating to help distribute heat evenly. It was the quickest at heating water on an induction hob, and Dupin noted that its handle made the pan very comfortable to use. It also cleaned up easily and felt solid.

WIRED Durable build quality; comfortable

TIRED Expensive

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£85, green-pan.co.uk

ULTRA MOTOR HYBRID 24

More of a moped than a bike, the Hybrid 24 is big in every way, from the battery pack to the in-hub motor. The bike does have relatively small 60cm wheels, which made it more manoeuvrable at low speeds. Its onboard computer has a charge indicator and trip counter, and you can choose between low, medium and high levels of assist. Setting the power level is fiddly and should only be done when stationary, but we found the medium setting to be more than enough to keep us at a steady 27kph with little effort.

WIRED Powerful

TIRED Heavy

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£1,800 ultramotor.com

KRANIUM RED LABEL

Kranium's bike looks great, and its battery integrates neatly into the frame. You power it up with a key, and control the functions via the computer. The bike has five pedal-assist speeds; the first two don't do much, but level three will have you cruising happily at 20kph, and four and five increase your speed to 24 and 27kph with a bit of pedal-power. The bike's also light enough to carry.

WIRED Very stylish

TIRED Battery-indicator cut-out

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£1,695 bikerepublicstore.co.uk

HOW WE TESTED

We took a selection of electric bikes to the Herne Hill Velodrome in south London, site of the 1948 Summer Olympics cycling events. We assessed handling, acceleration and cruising on its 450m track with 30° banked curves.

ULTRA MOTOR FAST4WARD PEAK

The Peak has the most flexible drivetrain in the group. A switch on the left handlebar lets you choose between high or low pedal-assist modes, or you can turn off automatic mode and use the twist throttle on the right handlebar. You can even ride around without using the pedals at all. However, there's some play in the transmission which leads to a jerk every pedal revolution at top speed.

WIRED Flexible drivetrain

TIRED Jerky cadence

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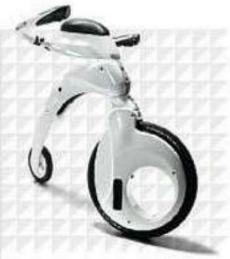
£1,200 ultramotor.com



YIKEBIKE CARBON

It's half the weight of the other bikes on test, folds up and has no pedals. To ride, you perch over the large front wheel with your arms at your sides on the handlebars, then squeeze the hand throttle to engage the power. The bike takes off briskly and can cruise at up to 23kph – it's terrifying at first, but you (sort of) get used to it. The short 10km range is a problem; this is a bike for riding to the station rather than the whole commute.

WIRED Portable

TIRED Takes practice

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£2,546 yikebike.com

GETTING UP TO SPEED

	HYBRID	KRANIUM	PEAK	YIKEBIKE	BH EMOTION
MAXIMUM SPEED (MOTOR ONLY)	24KPH	24KPH	24KPH	23KPH	24KPH
ASSISTANCE TYPE	PEDAL ASSIST	PEDAL ASSIST	PEDAL ASSIST/ THROTTLE	THROTTLE	PEDAL ASSIST
CLAIMED RANGE	64KM	64KM	64KM	10KM	90KM
RECHARGING TIME	4-5 HOURS	4-5 HOURS	4-5 HOURS	2 HOURS	3-4 HOURS
MOTOR POWER	250W	250W	250W	450W	350W
GEARS	7-SPEED SRAM 3.0 DERAILLEUR	7-SPEED SHIMANO DERAILLEUR	7-SPEED SHIMANO DERAILLEUR	N/A	8-SPEED SHIMANO ALIVIO
WEIGHT	27KG	17.5KG	21KG	11.5KG	21.8KG

PHOTOGRAPHY: SUN LEE; DAVE LIDWELL. WORDS: CHRIS FINNAMORE

PLUG IN, RIDE OFF

We take electric bikes for a ride

BH EMOTION NEO CROSS

Apart from the thick down tube (which houses the battery) there's little difference between the Neo Cross and a standard road bike. At any power setting above 50 per cent the bike pulled away sharply and could cruise at 27kph. The Tektro disc brakes provide plenty of stopping power. However, we found the low-slung safety pedals a problem; at one point they ground out on a shallow banking, pitching our test rider on to the concrete.

WIRED Brisk ride

TIRED Damaged knees

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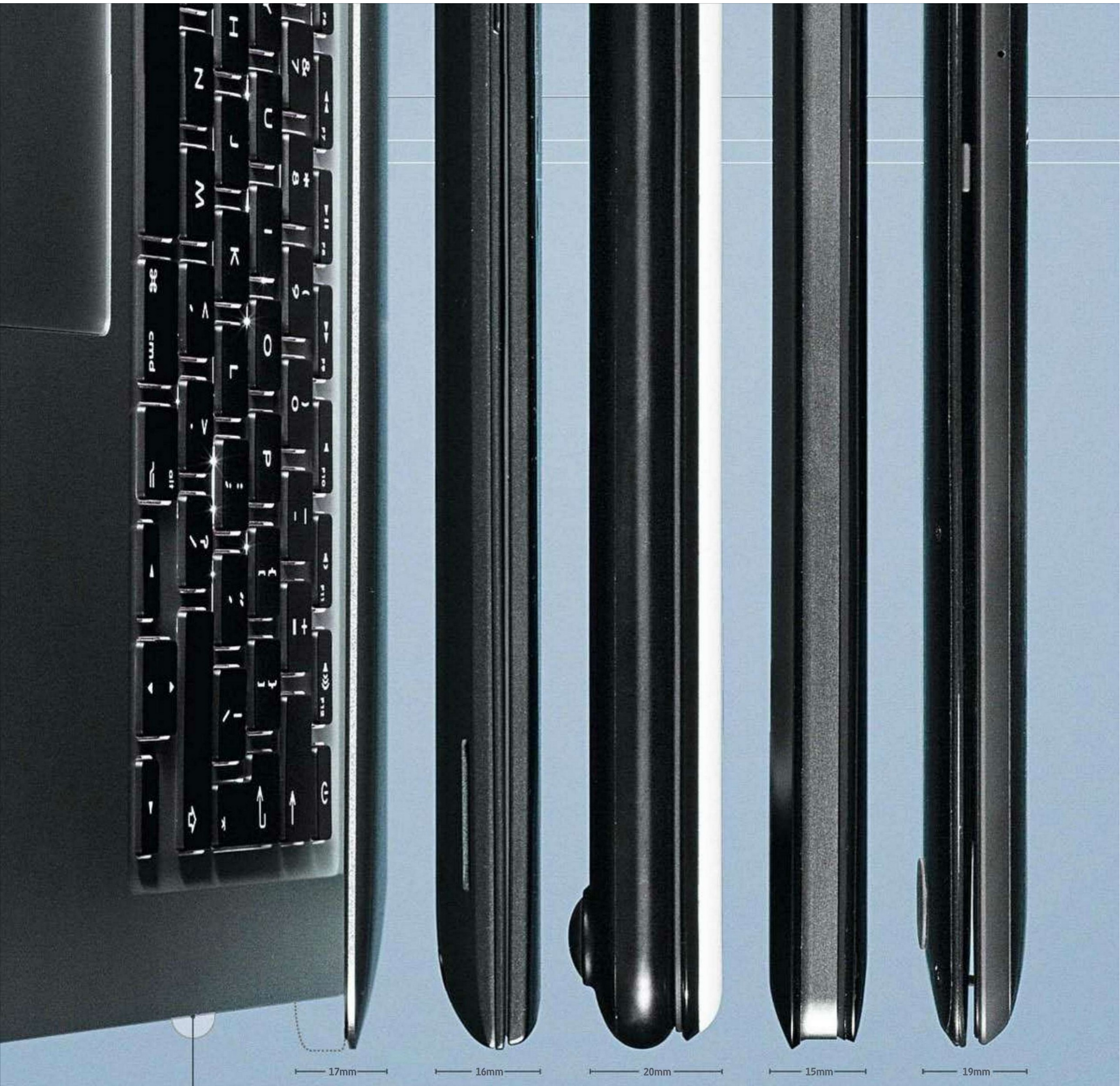
£1,899 bh-emotion.co.uk

The battery is detachable for recharging



SKINNY AND SMART

WIRED tests five super-slim laptops. But which ones need beefing up?

APPLE MACBOOK AIR 13"

An aluminium unibody makes the MacBook Air as sturdy as it is stylish, but it's also one of the fastest laptops available. The Air's 8hr 20min battery life is impressive and its backlit keyboard is fine for long typing sessions. However, the glossy screen is prone to catching reflections. When not on the road, the Air can easily connect to your desktop set-up. HD displays, external hard disks, DVD drives and other peripherals can daisy-chain to its super-fast, 20GB/s Thunderbolt port.

WIRED Power; looks

TIRED Shiny screen

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£1,099 apple.com/uk

PHOTOGRAPHY: SUN LEE; DAVE LIDWELL.
WORDS: JULIAN PROKAZA

SLIMLINE STATS

	APPLE	TOSHIBA	SAMSUNG	LENOVO	ASUS
PROCESSOR	INTEL CORE I5 (1.7GHZ)	INTEL CORE I5 (1.6GHZ)	INTEL ATOM N570 (1.66GHZ)	INTEL CORE I5 (1.6GHZ)	NVIDIA TEGRA 3 (1.4GHZ)
OS	MAC OS 10.7 LION	WINDOWS 7 HOME PREMIUM	GOOGLE CHROME OS	WINDOWS 7 HOME PREMIUM	ANDROID 3.2 HONEYCOMB
MEMORY	4GB RAM, 128GB SSD	4GB RAM, 128GB SSD	2GB RAM, 16GB SSD	4GB RAM, 128GB SSD	1GB RAM, 32GB SSD
WEIGHT	1.35KG	1.12KG	1.48KG	1.32KG	586G (1.12KG WITH DOCK)
COLD BOOT	16 SECS	18 SECS	8 SECS	15 SECS	45 SECS
BATTERY LIFE	8 HOURS, 20 MINS	8 HOURS	11 HOURS (21H WITH DOCK)	6 HOURS	5 HOURS, 30 MINS

TOSHIBA SATELLITE Z830-10U

The Satellite Z830 ultrabook has roughly the same specs as the MacBook Air – but shaves £200 off the price and almost 300g off the weight. However, its build quality is noticeably poorer: its aluminium body feels flimsy, and exposed screw-heads and a fan vent are unattractive. The keyboard is backlit, but the buttons look cheap. There are lots of ports, though, including HMDI and USB 3.0, and both performance and battery life are quite respectable. The anti-glare screen is also very effective under bright lighting.

WIRED Fast, light

TIRED Not a looker

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£899 uk.computers.toshiba-europe.com

SAMSUNG CHROMEBOOK SERIES 5

This is a low-cost option for working exclusively online – the Google Chrome OS provides little more than a web browser, and the bulk of your storage and software is hosted in the cloud. Simple operation and a cold-boot time of less than ten seconds are real pluses; less convincing is that it's near impossible to do anything without recourse to a website. Paying £50 more for a 3G model is a must.

WIRED Simplicity

TIRED Useless offline

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£299.99 (Wi-Fi only) samsung.co.uk

LENOVO IDEAPAD U300S

With a clean aluminium body, the Lenovo IdeaPad is the only Windows 7 ultrabook with looks to match Apple's. It's a shame it also shares its too-reflective screen, but the glass trackpad is wonderfully smooth. It has fewer ports than the Toshiba, but there is USB 3.0 and HDMI, plus WiDi for wireless HDMI to an HDTV. RapidCharge technology means the battery can reach 50 per cent charge in only 30 minutes.

WIRED Classy design

TIRED Too few ports

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£935 lenovo.co.uk

HOW WE TESTED

We measured performance using the Futuremark Peacekeeper test. Cold- and standby-boot times were recorded, and we played a looped video to assess battery life. We also took into account portability.

ASUS EEE PAD TRANSFORMER PRIME TF201

Tablets tend to trump laptops for portability, but aren't great for typing. The ASUS Transformer Prime blends iPad-tablet good looks with a practical qwerty keyboard dock. As a compact 10.1-inch Android laptop, it packs a powerful quad-core NVIDIA processor and a battery that lasted 21 hours in our test. An OS upgrade to Android 4.0 Ice Cream Sandwich is also imminent.

WIRED Versatile

TIRED No built-in 3G

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£499 asus.com

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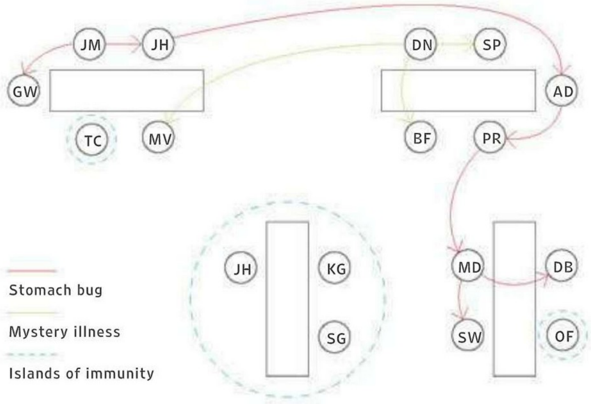
Overheard in the WIRED office:
"If you tickle a fish, you'll kill it. But you can hypnotise a lobster without endangering it."
"The casual Dalia is startup girl; smart Dalia is a VC investor."

Become a fan of our Facebook page (facebook.com/wireduk) and join the community. And don't forget the free, weekly podcast, too...

Extra credit:
Gero Miesenböck (p42) is pictured next to a MYbrain lamp by Alexander Lervik. *lervik.se.* Nik Nowak (p76) was shot at LokDock, Berlin. Michael Acton Smith (p96) wears a white cotton shirt by Charvet at MR PORTER, £260. Blazer by Dolce & Gabbana at MR PORTER, £610 *mrporter.com.* Second white cotton shirt by DKNY, £141 *dkny.com.*

Office numbers:
Assistant editor Madhu Venkataramanan's birthday was on February 29, making her our youngest staff member at six years old. **Test editor Jim Hill produced 184 pints of beer during his home-brewing kit tests.** During February, the WIRED office consumed 3.3kg of Nespresso coffee pods. So, yes, we're addicted – to recycling our pods, that is. **Fifteen seconds – the time tablet designer Kieran "Jack Bauer" Gardner asked for to redesign a page (he managed it in seven).**

Office contagion:
The WIRED office was swept by illness this month – around the same time that the Test editor retrofitted the kitchen as a microbrewery. Correlation or causation? And who gets to be Gwyneth Paltrow?



Sources for the Startup How To stats: [p94] doingbusiness.org **[p97]** doingbusiness.org **[p98]** doingbusiness.org **[p101]** Companies House 2011 annual report **[p103]** Companies House 2011 annual report **[p105]** 2010, Global Entrepreneurship Monitor **[p106]** 2010, Global Entrepreneurship Monitor **[p108]** cambridgestartupreport.com

Sources for the WIRED index: [p21] press.kelkoo.co.uk/britons-biggest-mobile-shoppers.html **[p23]** firstcare.eu **[p53]** nielsen.com **[p54]** theatlantic.com

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EXOvault. Pictured is the stunning Exo10 Brass and Pao Ferro wood iPhone 4s case by Exovault. Handmade in Brooklyn, New York, these luxury cases, as EXOvault say themselves, "A lot of people have iPhones, but not many people have the protection EXOvault cases." To find out more, call **218-227-3057** or visit **www.exovault.com** to see the full, luxury range.

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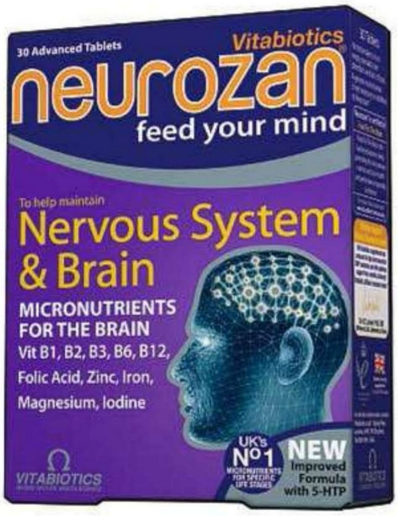
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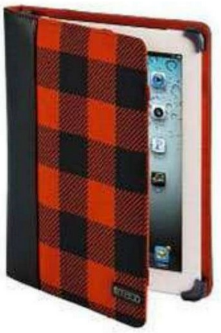

Featuring a classic plaid design, the Maroo Koe 2 iPad 2 case takes sophistication and turns it on its head. With its stylish nylon exterior and leather binding and back, the Koe 2 is one of our most popular iPad covers. It's jam-packed with features like smart magnet compatibility, a scratch-free interior, and multiple viewing angles.

Available at maroo.com and amazon.co.uk Email: info@maroo.com or call 360.883.0333

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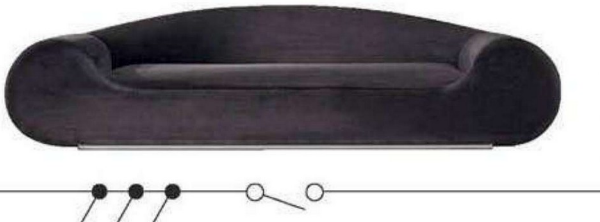

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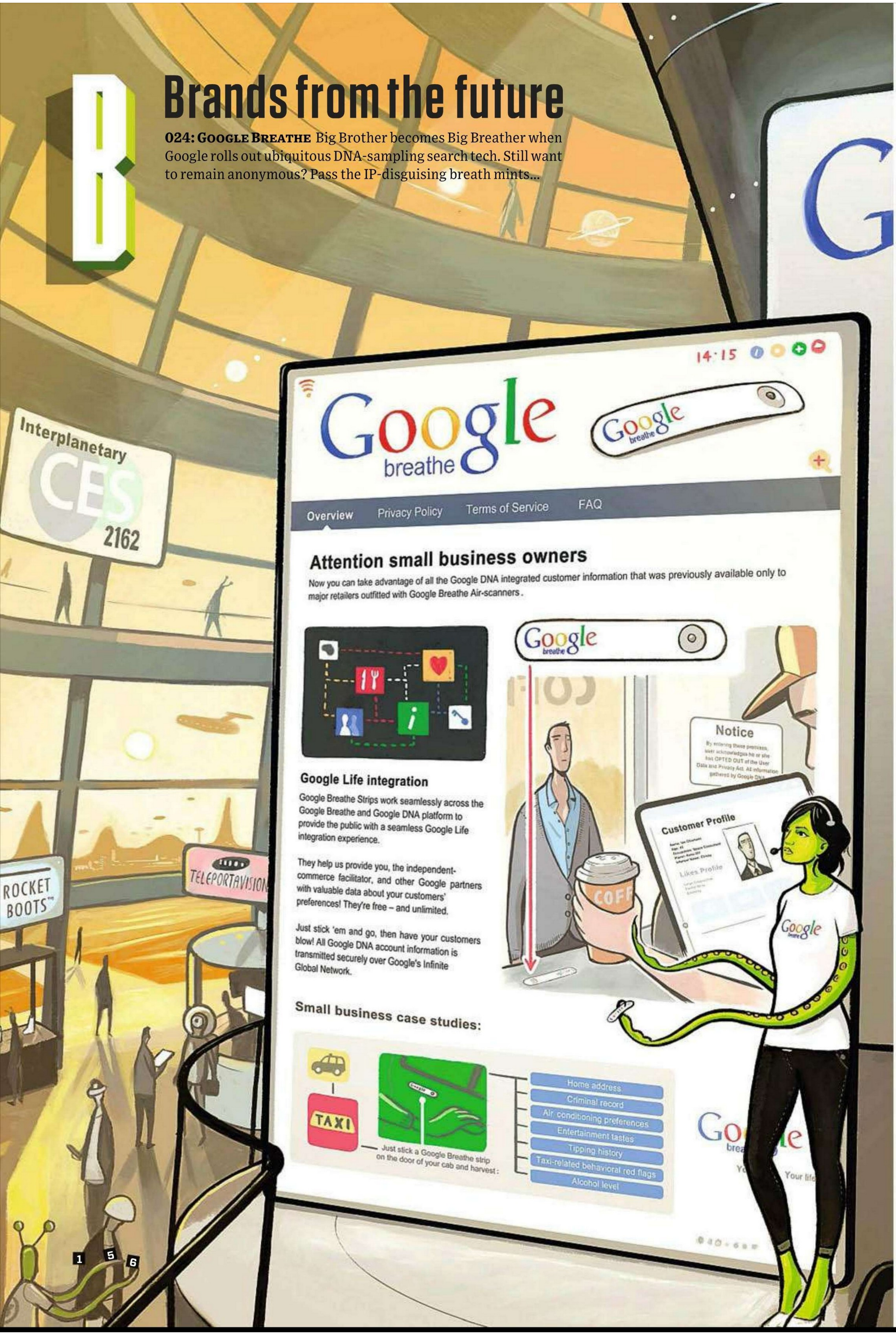
Brands from the future

024: Google Breathe Big Brother becomes Big Breather when Google rolls out ubiquitous DNA-sampling search tech. Still want to remain anonymous? Pass the IP-disguising breath mints...



Attention small business owners

Now you can take advantage of all the Google DNA integrated customer information that was previously available only to major retailers outfitted with Google Breathe Air-scanners.

Google Life integration

Google Breathe Strips work seamlessly across the Google Breathe and Google DNA platform to provide the public with a seamless Google Life integration experience.

They help us provide you, the independent-commerce facilitator, and other Google partners with valuable data about your customers' preferences! They're free – and unlimited.

Just stick 'em and go, then have your customers blow! All Google DNA account information is transmitted securely over Google's Infinite Global Network.

Small business case studies:

Just stick a Google Breathe strip on the door of your cab and harvest:

- Home address
- Criminal record
- Air conditioning preferences
- Entertainment tastes
- Tipping history
- Taxi-related behavioral red flags
- Alcohol level

ILLUSTRATION: STEPHEN COLLINS. Have you seen a brand from the future? Share your vision of tomorrow at *editorial@wired.co.uk*

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